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(54) Title: SYSTEM AND METHOD FOR DEFINING AND DISPLAYING A RESERVOIR MODEL

(57) Abstract: One embodiment of the present invention includes a method defining and displaying a reservoir model comprising, presenting in a graphical user interface, a series of windows walking a user through one or more steps necessary to generate a reservoir model definition and a simulation run definition. The method can also comprise presenting a set of results derived from the reservoir model definition and simulation run definition in the graphical user interface.

SYSTEM AND METHOD FOR DEFINING AND DISPLAYING A RESERVOIR MODEL

RELATED INFORMATION

This application claims priority under 35 U.S.C. 119(e) to provisional patent application No. 60/215,697, filed June 29, 2000, entitled "Method and System for Oil Reservoir Simulation and Modeling," which is hereby fully incorporated by reference.

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to reservoir modeling procedures and methods and more particularly to a system and method for defining and displaying a reservoir model.

BACKGROUND OF THE INVENTION:

Modeling of oil and gas reservoirs aid petroleum engineers in placing wells and increasing the efficiency of recovery operations. The numerical simulation techniques required to model a reservoir with a reasonable degree of accuracy, however, require the processing of a vast amount of data. Because of the processing requirements, high performance computers and sophisticated reservoir modeling programs are becoming increasingly important in the recovery of non-renewable energy resources.

Current reservoir simulation programs require that the user define a "mesh" so that the program can model the reservoir. In order to define a "mesh" which will result in an accurate model of the reservoir, the user of the program must have knowledge of numerical simulation techniques and computational fluid dynamics. While average petroleum engineers are highly skilled professionals, they often lack the training in these fields. Furthermore, current reservoir simulation programs do not provide a user-friendly graphical user interface in which to input the necessary data, making the programs time-consuming and frustrating to typical petroleum engineers.

Additionally, prior art reservoir simulation programs lack much of the functionality that field engineers desire. For example, prior art reservoir simulation programs do not allow field engineers to easily compare multiple simulations. Further, prior art reservoir simulation programs require significant post processing of the results of various simulations to analyze and compare the simulations. Furthermore, prior art systems do

not allow the field engineer to easily define multiple simulations without reentering a large amount of data.

SUMMARY OF THE INVENTION:

The present invention provides a system and method for defining and displaying a reservoir model that substantially eliminates or reduces disadvantages associated with previously developed systems and methods for defining and displaying reservoir models. In particular, one embodiment of the present invention provides a system and method for defining and displaying a reservoir model comprising a software program executable by a computer processor to provide a graphical user interface that displays a series of windows walking a user through all of the steps necessary to provide a reservoir model definition and a simulation run definition. The graphical user interface can also display a set of results derived from the reservoir model definition and a simulation run definition. The software program can be further executable to receive the reservoir model definition and simulation run definition from the user.

The embodiments of the present invention provide a substantial advantage over previously developed systems for defining and displaying reservoir models by allowing a user to define multiple reservoir model definitions and simulation run definitions.

The embodiments of the present invention provide another substantial advantage over previously developed systems for defining and displaying reservoir models by allowing the user easily manipulate reservoir model definitions and simulation run definitions.

The embodiments of the present invention provide yet another substantial advantage by allowing a user to quickly and easily modify reservoir model definitions.

The embodiment of the present invention provide yet another substantial advantage over previously developed systems for defining and displaying reservoirs by allowing a user to define a reservoir without having extensive knowledge of reservoir modeling techniques or computational fluid dynamics.

The embodiment of the present invention provide yet another technical advantage over previously developed systems of defining and displaying reservoir models by allowing a user to quickly and easily provide reservoir model definitions.

The embodiment of the present invention provide yet another technical advantage over previously developed systems of defining and displaying reservoir models by allowing the user to quickly and easily compare the results of multiple simulation runs.

The embodiments of the present invention provide yet another technical advantage over previously developed systems of defining and displaying reservoir models by directly presenting the user with data that is pertinent to field users.

The embodiments of the present invention provide yet another technical advantage over previously developed systems of defining and displaying reservoir models by providing the user with substantial time savings over previously developed systems.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention and the advantages thereof may be acquired by referring to the following description, taken in conjunction with the accompanying drawings in which like reference numbers indicate like features and wherein:

FIGURE 1 is a diagrammatic representation of a system for defining and displaying reservoir models according to the present invention;

FIGURE 2 is a screen shot of one embodiment of a graphical user interface according to the present invention;

FIGURE 3 is a screen shot of one embodiment of a graphical user interface at the beginning of a new project;

FIGURE 4 is a screen shot of one embodiment of a graphical user interface displaying a 2-D editor according to the present invention;

FIGURE 5 is a screen shot of a graphical user interface displaying a zone layer editor according to the present invention;

FIGURE 6A is a screen shot of one embodiment of a condition editor dialog box according to the present invention;

FIGURE 6B is a screen shot of another embodiment of a condition editor dialog box according to the present invention;

FIGURE 6C is a screen shot of yet another embodiment of a condition editor dialog box according to the present invention;

FIGURE 7 is a screen shot of one embodiment of a PVT edit dialog box according to the present invention;

FIGURE 8 is a screen shot of one embodiment of a dialog box for creating time slices of an archived model according to the present invention;

FIGURE 9 is a screen shot of another embodiment of a graphical user interface according to the present invention;

FIGURE 10 is a screen shot of one embodiment of a graphical user interface displaying a 2-D editor according to the present invention;

FIGURE 11 is a screen shot of one embodiment of a zone layer editor according to the present invention;

FIGURE 12 is a screen shot of one embodiment of a well definition window according to the present invention;

FIGURE 13 is a screen shot of one embodiment of a graphical user interface for defining fluid properties according to the present invention;

FIGURE 14 is a screen shot of one embodiment of a graphical user interface for displaying a well conditions window according to the present invention;

FIGURE 15 is a screen shot of one embodiment of a graphical user interface for displaying a model parameters window according to the present invention;

FIGURE 16 is a screen shot of one embodiment of a graphical user interface according to the present invention;

FIGURE 17 is a screen shot of one embodiment of a graphical user interface at the beginning of a new project;

FIGURE 18 is a screen shot of one embodiment of a graphical user interface displaying a 2-D editor according to the present invention;

FIGURE 19 is a screen shot of a graphical user interface displaying a zone layer editor according to the present invention;

FIGURE 20A is a screen shot of one embodiment of a condition editor dialog box according to the present invention;

FIGURE 20B is a screen shot of another embodiment of a condition editor dialog box according to the present invention;

FIGURE 21 is a screen shot of one embodiment of a PVT edit dialog box according to the present invention;

FIGURE 22A-22C are a screen shots for embodiments of a dialog boxes for defining a simulation run definition.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention are illustrated in the FIGUREs, like numerals being used to refer to like and corresponding parts of various drawings.

Computer simulations of oil and gas reservoirs provide petroleum engineers with valuable insights into placing wells in the reservoir and increasing the production efficiency of recovery operations from the reservoir. The present invention provides a system for defining and displaying computer models of reservoirs. Because the present invention provides a user-friendly graphical user interface for defining and displaying models of reservoirs, petroleum engineers can easily define reservoir models, create multiple simulations and view and compare the results of the simulations.

FIGURE 1 is a diagrammatic representation of a system 100 for defining and displaying reservoir models according to an embodiment of the present invention. In system 100, a software program 110 residing on a computer-readable medium 120 is executable by a computer processor 130 to display a graphical user interface 135 in display device 140. Through graphical user interface 135, a user can provide a set of project data that can be used to define a reservoir model and a simulation run. The reservoir model definition defines the physical characteristics of the reservoir that the user is attempting to model, whereas the simulation run definition defines how the modeler program 150 will model the reservoir, including time constraints and/or boundary conditions. Software program 110 can then forward the reservoir model and/or the simulation run to modeler program 150. Modeler program 150 can model the reservoir based on the

simulation run definition and the reservoir model definition and return a set of results to software program 110. The set of results can be displayed in graphical user interface 135 by software program 110. It should be noted that while software program 110 and modeler program 150 are shown as being separate in FIGURE 1, they can be part of an integrated software package. Furthermore, while system 100 only illustrates one computer for the sake of simplicity, the functionality of system 100 can be distributed over many computers in a network.

FIGURE 2 is a screen shot of one embodiment of graphical user interface 135 according to an embodiment of the present invention. Graphical user interface 135 can include a project data window 210, a reservoir model window 220, a simulation window 230, and a display window 240. Graphical user interface 135 can also include a menu toolbar 250 for presenting pull-down menus and icons to represent the most commonly used functions from the menu bar. As illustrated in FIGURE 2, project data window 210 can include a project data tree 255. Project data tree 255 can include a series of elements, such as geometry element 257 and wells element 259, to categorize the project data. In one embodiment of the present invention, a user can click on an element, such as geometry element 257, to display a pop-up context menu relating to. the element. For geometry element 257, this might include a pop-up menu with "create new reservoir," "cut," "paste" or other such options. Project data window 210 can include data elements provided by the user to define the reservoir model definition and a simulation run definition. As one example, a user could provide data regarding the boundaries of a reservoir, which could be represented by the element 265 labeled "zone boundary 1." As will be discussed in greater detail below, the user can provide other sets of project data relating to a reservoir or to a simulation run.

Along with displaying project data in graphical user interface 135, a reservoir model definition can be displayed in reservoir model definition window 220. In reservoir model definition window 220, a reservoir model tree 270 can be displayed. Reservoir model tree 270 can be used to categorize and organize data relating to a particular reservoir model definition. If a user wishes to define a particular reservoir model definition (e.g. in reservoir definition window 220) upon which a simulation could be based, the user could populate reservoir model definition using elements contained in the project data (e.g., elements from project data tree 255). In one embodiment of the present invention, this could be done by dragging and dropping elements from project data

window 210 into reservoir model definition window 220. Thus, for example, if a user wanted to run a simulation on a reservoir model having a zone boundary corresponding to "zone boundary 1," the user could drag element 265 from project data window 210 into reservoir model definition window 220. In this example, after being dragged and dropped, the user will see element 275 in reservoir model definition window 220. The user can similarly drag and drop other elements from the project data window 210 into reservoir model definition window 220 to fully define a reservoir model definition. This allows the user to use the elements contained in project data window 210 as the basic building blocks for various reservoir model definitions.

In addition to displaying project data and a reservoir model definition, graphical user interface 135 can display a simulation run definition. In simulation window 230, the user can define various simulation run definitions for modeling a reservoir, and simulation window 230 can include a simulation run tree 280 to categorize the various elements of simulation run definitions. In one embodiment of the present invention, the user can define a simulation run by dragging and dropping a reservoir definition from reservoir definition window 220 and elements, from project data window 210, into simulation window 230. In this manner, the user can use various reservoir model definitions and elements from the project data to define multiple simulation run definitions simply by dragging and dropping elements from one window into another without having to actually re-enter data.

Once a simulation run definition has been defined, modeler program 150 can model the reservoir and return a set of results, which can be displayed in simulation window 230 (e.g., element 283). The results can then be dragged into display window 240 and be shown in various formats, including a two-dimensional model, a three-dimensional model, or charts and graphs displaying various properties of the modeled reservoir.

In addition to displaying the results returned by modeler program 150, display window 240 can include a 2-D editor 290. As will be discussed below, the user can use 2-D editor 290 to define various elements in the set of project data displayed in project data window 210. Display window 240 can also include a 3-D viewer 292. In one embodiment of the present invention, the user can drag a reservoir model definition into the 3-D viewer, and the 3-D viewer will display a three-dimensional view of the reservoir model. This can aid the user in visualizing the model and in correcting errors in the reservoir model definition. Additionally, display window 240 can also include a chart

viewer 294 which can be used to display various charts and graphs related to the reservoir model definition, the simulation run definition, or the results returned by the modeler program. Again, the display in chart viewer 294 can be prompted by the user dragging and dropping an element into chart viewer 294. Thus, for example, if the user dragged and dropped the results from one simulation run into chart viewer 294, chart viewer 294 would display various properties related to that simulation run. If user dragged and dropped the results from a second simulation run into chart viewer 294, chart viewer 294 could show a comparison of the results between the two simulation runs.

As can be easily understood from the above discussion, graphical user interface 135 provides an easy, user-friendly interface for users to provide a reservoir model definition and to display the results of modeling a reservoir. Because graphical user interface 135 can include drag-and-drop functionality, a user can easily build new reservoir model definitions from extant elements in a set of project data and, likewise, can easily build new simulation runs from various reservoir model definitions or elements in the project data. Thus, the user can easily create several reservoir model definitions and multiple simulation runs without having to enter new data. Furthermore, graphical user interface 135 can provide an aesthetic and well-organized system for displaying data related to the modeling of a reservoir.

To better aid in an understanding of the ease and simplicity of the present invention for defining and displaying a reservoir model, FIGUREs 3-8 illustrate screen shots of one embodiment of graphical user interface 135 during various stages of a user defining and displaying the reservoir model definition and the results of a simulation run.

In one embodiment of the present invention, when a user is interested in creating a new project, the user can click on the file menu on the menu toolbar 250 and then click on "new" in the file pull-down menu. This functionality should be familiar to any computer user who has created a new document in common word processing applications such as Microsoft Word. After a user has clicked on the file and new options as previous described, the user can be given an option of naming his project and giving the project a directory location where the project file can be kept. In addition to naming the project, the user can be given the option in a dialog box (not shown) to select an appropriate physics module and customize the module's global constraints if necessary. Physics

modules can be used to define the internal physics of a reservoir and can include, for example, one phase gas 3D, one phase gas 4D, two phase 3D, etc.

FIGURE 3 illustrates a screen shot of one embodiment of graphical user interface 135 according to the present invention after the user has opened a new project and selected a name for the project. When the new project is created, project data window 210, reservoir model definition window 220, and simulation window 230 can be initialized without any data. As can be seen in FIGURE 3, project data tree 255, reservoir model definition tree 270, and simulation run tree 280 are empty (e.g. none of the elements in project data tree 255, such as "geometry" have been populated with data). To begin defining the set of project data, the user can click on the view option of menu toolbar 250 to pull down a view menu. The user could then click on a "map" view option in that pull-down menu. This can cause 2-D editor 290 to be displayed in display window 240.

FIGURE 4 shows a screen shot of one embodiment of graphical user interface 135 according to the present invention with 2-D editor 290 displayed in display window 240. Using 2-D editor 290, the user can create, edit, and display zone boundaries. Similar to other computer drawing tools, the user will be able to create poly-lines, by simply clicking on points in 2-D editor 290. Alternatively the user can crate zone boundaries using ellipses, polygons, etc., or the user can load zone boundaries that are stored in a compatible file format such as a spreadsheet. When a user is finished defining a zone boundary, such as zone boundary 401, a pop-up dialog can prompt the user to name the new zone boundary. The name of the new zone boundary can then appear in graphical user interface 135 (e.g., element 407 represents "zone boundary 1"). The user can then define additional zone boundaries for the reservoir model definition.

In addition to defining zone boundaries in 2-D editor 290, the user can provide well definitions. In one embodiment of the present invention, when the user clicks on well element 410 of project data tree 255, a context menu with a "create well" option could appear. After clicking on the "create well" option, a dialog box (not shown) could appear asking the user to input well properties, such as inner and outer radius of the well and other relevant information used by modeler program 150 to create a finite elements mesh around the well. The user can specify whether the well is an injector or a producer and name the well. The well can be displayed as an element under well

element 410 of project data tree 255. The user could then select the location of the well by placing an icon representing the well in the 2-D editor 290 (e.g., well icon 420).

From 2-D editor 290, the user can also create, edit and display zone points. Zone points are points that will be honored during the automatic meshing process. The user can click zone points into existence by clicking on points in 2-D editor 290. In one embodiment of the present invention, the user can toggle 2-D editor 290 into showing the mesh that modeler program 150 will apply to the reservoir model. Furthermore, the user can instantaneously see a re-mesh as the user adds or removes zone points from 2-D editor 290.

In addition to using 2-D editor 290 to define zone boundaries, wells and zone points, a user can specify the reservoir properties at various points in the reservoir. From project data tree 255, the user can click on property maps element 415 and select "create data property map" option from a pop-up context menu. After selecting "create data property map," a dialog box can prompt the user to name the new property map, as well as enter the units of the property being entered. The user could then click on points in 2-D editor 290 to specify points associated with the new property map. For each point, the user can specify the property value for that point. Examples of reservoir properties that can be included in the property map include things such as permeability of the reservoir in the X direction, the porosity of the reservoir, or the thickness, etc. Thus, a user can define the porosity of the reservoir at different locations by clicking on various points in 2-D editor 290 and assigning those points a porosity value. Alternatively, the user can assign constant porosity values to the reservoir (e.g., the reservoir could have a constant porosity throughout).

Along with defining zone boundaries, zone points, wells and property maps, the user can define zone layers using graphical user interface 135. A zone layer corresponds to the depth and thickness of a particular zone in a reservoir. From project data tree 255, the user can click on zone layers element 430 to call up a context menu. In the context menu, the user can select a "create zone layer" option, prompting a zone layer editor to appear in display window 240. FIGURE 5 is a screen shot of one embodiment of zone layer editor 500 according to the present invention. In zone layer editor 500, the user can create zone layers and specify the base and top depths of each layer. The user can either define the layers in layer graphic 510 by moving the depth bars 520 up and down or can directly enter the layer depth in the fields provided. Additionally, the user

can drag property maps from project data tree 255 onto the layers to associate the property maps with the layers. For example, if a property map had been previously created named "Property Map 1," and was stored under property map element 420 of FIGURE 4, Property Map 1 could be dragged into layer editor 500 and dropped into layer 2. This would associate Property Map 1 with layer 2. Alternatively, the user can also define zone layers by entering data in zone layer fields 530.

A user can also define conditions for zone boundaries, wells and zone layers. The user can select the zone boundary, well or zone layer from project data tree 255, 2-D editor 290 or layer editor 500 and display a pop-up context menu. From the pop-up context menu the user can select a "create condition" option to create a new condition set. A condition editor dialog box can appear in display window 240 that allows the user to create outer boundary conditions, well conditions, initial conditions, and interior conditions and them insert them into a selected condition set. FIGUREs 6A through 6C show screen shots of one embodiment of the condition editor dialog box according to the present invention. FIGURE 6A shows a dialog box for specifying initial conditions, FIGURE 6B shows a dialog box for specifying outer boundary conditions, and FIGURE 6C shows a dialog box for specifying well conditions. As can be seen in each of these figures, a condition set name field 610 can be used to specify the conditions set to which a particular condition belongs. The name of the conditions set can appear in project data window 210 under conditions set element 430 (see FIGURE 4).

In one embodiment of the present invention, the user can also define rock and fluid properties. In response to the user clicking on the "create pvt items" option in a context pop-up menu, a pvt edit dialog box can appear. FIGURE 7 illustrates a screen shot of one embodiment of the pvt edit dialog box 700 according to the present invention. In pvt edit dialog box 700, the user can specify such rock and fluid properties for a reservoir such as the pressure, volume, temperature, relative permeability and the capillary pressure. When data has been entered in the fields in window 710, the user can create charts, such as chart 720, to visualize what was just entered.

From project data tree 255, the user can also create a set of timeframes. The timeframes can include a description of how the model of the reservoir will be extruded by a modeler program in a time dimension. To enter the timeframes, a dialog box very similar to the zone layer editor 500 of FIGURE 5 can be used. In the timeframe dialog

box, a user could define time layers, either by directly entering time layer data or by manipulating a timeframe graphic.

Additionally, a user can click on solver element 440 in project data tree 225 to create a set of solver properties. From a pop-up context menu, the user can select "create solver properties," which can prompt a solver properties dialog box to be displayed in display window 240. FIGURE 8 illustrates a screen shot of one embodiment of the solver properties dialog box 800 according to one embodiment of the present invention. Solver properties can be used to control how a reservoir is modeled by modeling program 140. Solver properties can include items such as error estimations, number of iterations, tolerances, etc. As can be seen from FIGURE 8, a solver property name can be used to identify a particular set of solver properties.

Returning again to FIGURE 2, FIGURE 2 illustrates one embodiment of the graphical user interface 135 according to the present invention, in which the project data tree 255 has been populated with data entered by a user. In one embodiment of the present invention, the data can be entered by the user in the manner described in conjunction with FIGUREs 2 through 8. To define the reservoir model definition in this embodiment of the present invention, the user can drag and drop elements from project data tree 225 into reservoir model definition tree 270. By dragging and dropping different combinations of elements from project data tree 225 into reservoir model tree 270, the user can define several reservoir model definitions.

In order to view the reservoir model that is defined by the reservoir model definition, the user can drag the reservoir model definition into the 3-D display window 292. 3-D display window 292 can be called up, for example, by the user clicking on the view option in menu toolbar 250 and then clicking on a 3-D viewer option in the corresponding pull-down menu. In one embodiment of the present invention, by dragging a reservoir model definition, such as the "reservoir 1" definition (e.g., element 277) into 3-D viewer 292, 3-D viewer 292 will display a 3-D view of the reservoir defined by reservoir model definition 1. Furthermore, by dragging and dropping a different set of elements from project data tree 255, the user can define additional reservoir model definitions. For example, a reservoir model definition 2 (e.g., element 278).

Similarly, the user can define multiple simulation run definitions. In one embodiment of the present invention, this can be done by the user dragging and dropping a reservoir model definition (e.g., reservoir model definition 1) into simulation run tree 280. As can

be seen, reservoir model definition 1 is contained in run simulation definition 3 (e.g., element 281). The user can further define a simulation run definition by dragging and dropping a conditions set from project data tree 255 and dropping it into simulation run definition tree 280. The user can also drag and drop a set of solver properties from project data tree 255 to simulation run tree 280.

After defining a simulation run definition, the user can run the simulation run by, for example, selecting a run option from a simulation run context menu. The selected simulation runs can then be processed by modeler program 150. Once a simulation run has been completed, the reservoir model which was created by the simulation run can be archived. For example, FIGURE 2 shows that reservoir 1 has been modeled and is archived under results element 283 of the simulation runs tree 280. A user can then drag and drop the archived results into 3-D viewer 292 to view the modeled reservoir.

In one embodiment of the present invention, the archived model can also be dragged and dropped into chart viewer 294 of graphical user interface 135. Chart viewer 294 can display charts and graphs that are pertinent to field engineers, such as formation volume factor versus pressure, viscosity versus pressure, solution gas ratio versus pressure, relative permeability versus saturation, or capillary pressure versus saturation. Additionally, chart viewer 294 can provide well production time series plots which can give the user insight into the production of a given well over time. Examples of well production time series plots include production of phase rates, ratios, and cumulative phase volume charts. Furthermore, chart viewer 294 can allow the user to display user defined charts so that the user can plot one property of a given reservoir against another property. In addition, a user can drag and drop multiple archived reservoir solutions into chart viewer 294 so that the results from various reservoir models can be directly compared by the user. To further aid in analysis of the archived model, the archived model can also be sliced with the predefined slice operations. FIGURE 8 shows one embodiment of a dialog box 800 for creating slices of the archived model according to the teachings of the present invention. As illustrated in FIGURE 8, both time slices and well slices can be made by the user.

As can be understood from the foregoing discussion, the present invention can provide a user-friendly system and method for defining and displaying computer simulation models of reservoirs. The present invention can allow a user to define the basic

building blocks for reservoir models and to then easily combine those building blocks into different reservoir models without having to re-enter large amounts of data. Additionally, the present invention can allow a user to define several sets of parameters for simulation run definitions and to then define multiple simulation run definitions using various sets of parameters and the different reservoir models defined by the user.

In one embodiment of the present invention, the defining of the reservoir model definitions and simulation run definitions can be done through a series of user-friendly dialog boxes and graphics tools. Furthermore, the reservoir model definition and simulation run definition can easily be defined by dragging and dropping various components of the definitions from a set of project data.

Because the actual modeling of the reservoir occurs in the background, a user does not need extensive knowledge of modeling techniques. Furthermore, the type of data entered in project data tree 255 is the type of data that would be generally known and understandable to petroleum engineers or workers out in the field, making the present invention exceptionally easy to use. Thus, the present invention provides substantial advantages over the prior art by allowing the user to define and display a computer simulation of a reservoir in a user-friendly manner. Furthermore, the present invention provides another advantage because the present invention allows the quick display of the type of information that is directly useful by reservoir engineers working in the field.

In another embodiment of the present invention, graphical user interface 135 can present a user with a series of windows walking the user through all the steps necessary to define a reservoir model definition in the simulation run definition. In this embodiment, graphical user interface 135 can automatically present the user with a series of windows to guide the user through defining a reservoir model definition and a simulation run definition, whereas in the embodiment described in conjunction with FIGUREs 2-8, the graphical user interface would present dialog boxes when called by the user. It should also be noted, however, that the windows can be presented in any order, and that the sequence provided below is exemplary only. FIGURE 9 is a screen shot of one embodiment of graphical user interface 135 according to the present invention. Graphical user interface 135 can include a tool bar 905 containing commonly used functions, a project window 910 containing a reservoir model tree 915, having various previously defined reservoir definitions and simulation run definitions, and results window 915 containing a results tree 925, representing the results of

previously run simulations. Graphical user interface 135 can also include a display window 920 for displaying various windows to walk a user through providing a reservoir model definition and a simulation run definition.

In operation, to begin defining a new reservoir model definition, the user can click on the "file" button in toolbar 905 and then on a "new" option in the context pop-up menu that appears when the user clicked on the file button. In response to the user clicking on "file" and "new," graphical user interface 135 can display a zone boundary definition window with a 2-D editor. FIGURE 10 is a screen shot of one embodiment of graphical user interface 135 with 2-D editor 290 displayed in display window 920. As previously discussed with regards to FIGURE 4, the user can create, edit and display zone boundaries such as zone boundary 1005 in 2-D editor 290. Similar to other computer drawing tools, the user will be able to create poly-lines by simply clicking on points in 2-D editor 290, or the user can define zone boundaries using predefined shapes, such as predefined shapes 1010, displayed in the toolbar 1015 of 2-D editor 290. In addition to displaying 2-D editor 290, graphical user interface 135 can display a set of zone boundary definition fields 1020 that are linked to a two dimensional shape drawn in 2-D editor 290. Thus, the user can enter the coordinates of a zone boundary either by drawing the zone boundary in 2-D editor 290, by entering points along the zone boundary in a set of fields 1020 or, as previously discussed, by importing a zone boundary from a compatible file format. Additionally, in the zone boundary definition window, the user can enter a name of the zone boundary by using name fields 1025, in this case, "CircularReservoirBoundary." Graphical user interface 135 can also display a task list 1030 which gives the status of the various steps in specifying a reservoir model definition in a simulation run definition. The user can click on an item in task list 1030 to skip to a particular step in defining the reservoir model definition or simulation run definition. When the user has finished defining the reservoir boundaries, the user can click on the finish button 1035 to move onto the next step.

When the user clicks on the finished button 1035, graphical user interface 135 can display a zone layer definition window as illustrated in FIGURE 11. The zone layer definition window can include a task list 1130 specifying the tasks that should be completed in defining the reservoir model definition in the simulation run definition. Additionally, the zone layer definition window can include a zone layer graphic 1110. As with layer graphic 510 discussed in conjunction with FIGURE 5, a user can define

the depth of zone layers by moving depth bars in graphic 1110 up and down, or the user can directly enter the thickness of the layer by defining the top elevation and the bottom elevation of the layer in elevation fields 1115 and 1120 respectively. Additionally, in zone layer property area 1130, the user can define various conditions present in the zone layer. For example, the user can define the X permeability, the Y permeability, the thickness of the layer, the porosity, etc. Additionally, in map type check boxes 1125, the user can check whether particular zone conditions are constant, scattered or correspond to some pattern such as a grid. In the case in which the zone conditions correspond to a grid pattern, the user can import a grid from another software program in a compatible format. Furthermore, in layer name box 1135, the user can provide a name for a particular zone layer. This process can be repeated for multiple zone layers in the same reservoir model definition. When the user has finished defining the conditions for all the zone layers in the reservoir, the user can click on finished button 1140.

After the user has defined the zone layer conditions (see, FIGURE 11), graphical user interface 135, as shown in FIGURE 12, can display a well definition window. The well definition window can, again, include a 2-D editor 290 through which the user can define the placement of a well in the reservoir. Additionally, the user in well property area 1203 can define whether the well is a producer or an injector (checkbox 1205) and can define a well's inclination (checkbox 1210). Also, by clicking on the tabs provided (e.g. tubing model and completion), the user can define other well properties, as would be understood by those of ordinary skill in the art. In addition, in field 1215, the user can define the well radius and in field 1220 the user can name the well. Additionally, in well definition field 1225, which can be linked to 2-D editor 290, the user can define various points for the location of wells. When the user is finished defining various wells, the user can click on finish button 1230 and proceed to the next step in defining the reservoir model.

As shown in FIGURE 13, the user can next define fluid properties for the reservoir model. FIGURE 13, is a screen shot of one embodiment of graphical user interface 135 for defining the fluid properties according to the present invention. In fluid properties area 1303, a user, via property fields 1305, can define such fluid properties as the initial reservoir pressure, reservoir temperature, separator gas gravity, condensate gravity, and other reservoir fluid properties that can be determined to be known to those of

ordinary skill in the art. In chart viewer 1310, the user can view charts illustrating various fluid properties selected by the user. Chart viewer 1310, in one embodiment of the present invention, can show a generated graph of the pressure, formation volume factor, and viscosity for a reservoir. Graphical user interface 135 can provide name field 1315 through which the user can name a particular set of fluid properties. The user can then proceed to the next step in defining the reservoir model definition by clicking on the finish button 1320.

FIGURE 14 is a screen shot of one embodiment of graphical user interface 135 for displaying a well conditions window, according to the present invention. In well condition name field 1405, the user can name the well conditions that he or she is defining for a particular well. In well properties area 1407, the user can determine to which well the condition is going to be applied (field 1410) and define the specific well conditions (well condition fields 1420). Chart viewer 1425 can graphically display the well conditions in chart format for review by the user. When the user is finished defining the well conditions for the various wells in a reservoir model definition, the user can click on finish button 1430 to proceed to defining the simulation run definition.

FIGURE 15 shows a screen shot of graphical user interface 135 for displaying one embodiment of a model parameters window according to the present invention. In name field 1505, the user can provide a name for a simulation run and in description field 1510 provide a brief description of the simulation run. Additionally, in model run time frame fields 1515, the user can specify the time and date to begin a simulation run and the time that the simulation run should end. Furthermore, in reservoir elevation and initial pressure fields 1520, the user can define the pressure at a reference elevation. In fields 1525, the users can indicate whether they are interested in displaying time slices of a model and the times for which they wish to view the time slices. Additionally, in chart area 1530, the user can check off which charts they wish to view after the simulation run is complete. In this example, the user has indicated that he or she wishes to see the pressure and rate charts for the well named "well" of the reservoir, and the pressure rate and cumulative charts for the well named well one for the reservoir. When the user has completed entering all the model parameters, the user can click on the run button 1550 to run the simulation. Results of the simulation can be displayed in graphical user interface 135 in chart format, graph format or as a 3-D model. Referring again to FIGURE 9, the results from the most recent simulation. or

a previous simulation, can be represented in results window 915. By clicking on the results shown in results window 915, the user can view the set of results associated with a particular simulation run. Various charts and three-dimensional views of the simulation run can be displayed in display window 920.

In addition to allowing a user to easily define a reservoir model, the present invention can allow a user to resume creating a reservoir model definition. If a user wishes to return to a project, they can open a saved reservoir model definition and continue to define the reservoir model or redefine elements of the reservoir model. In one embodiment of the present invention, for a reservoir model that has already been simulated, model program 150 can simply perform calculations for elements that have been redefined rather than rerunning the entire model. Additionally, the present invention can resume a terminated simulation run at the point where the simulation was previously terminated by a user. The user, therefore, does not have to reenter an entire reservoir model definition and can thus save substantial time.

As could be understood from the forgoing discussion, the user does not need any significant knowledge, if they need any knowledge at all, of computational fluid dynamics or of reservoir modeling techniques. Instead, the user need only understand concepts that are familiar to most petroleum field engineers, such as field boundaries, layer definitions, reservoir properties, fluid properties, initial conditions, etc. Additionally, graphical user interface 135 can walk a user through the various steps in defining a reservoir model definition in a simulation run definition. In this manner, the graphical user interface of the various embodiments of this invention can obviate the need for a user to have detailed knowledge of reservoir modeling. Because graphical user interface 135 can walk a user through the steps of reservoir modeling, graphical user interface provides a simple user-friendly method to define reservoir models and to conduct simulations. Graphical user interface 135 also allows the user to define various models and simulation run definitions so that users can create a variety of reservoir models, allowing the user to experiment with reservoir characteristics and to plan for various contingencies.

FIGURE 16 is a screen shot of yet another one embodiment of graphical user interface 135 according to an embodiment of the present invention. Graphical user interface 135 can include a combined reservoir model and simulation window 1620 and a display window 1640. Graphical user interface 135 can also include a menu toolbar 1650 for

presenting pull-down menus and icons to represent the most commonly used functions from the menu bar. In one embodiment of the present invention, a user can click on various elements, such as geometry element 1657, to display a pop-up context menu relating to the associated element. For geometry element 1657, this might include a pop-up menu with "create new reservoir," "cut," "paste" or other such options. Window 1620 can include data elements provided by the user to define the reservoir model definition and a simulation run definition (e.g., the definition of reservoir model and how that model should be acted upon by modeler program 150). As one example, a user could provide data regarding the boundaries of a reservoir, which could be represented by the element 1665 labeled "Reservoir Boundary 1." As will be discussed in greater detail below, the user can provide other sets of model data relating to a reservoir or to a simulation run. It should be noted, that in this embodiment of the present invention, graphic user interface 135 no longer includes a mixed collection of model pieces that can be assembled into reservoir model definitions on an ad hoc basis, but instead contains a representation of complete or partially complete models that can be dragged and dropped between various simulation run definitions).

In window 1620, a model tree1670 can be displayed. Model tree 1670 can be used to categorize and organize data relating to particular reservoir model definitions and simulation run definitions. It should be noted that in FIGURE 16, only one reservoir model definition and simulation run definition are categorized. However, additional reservoir model definitions and simulation run definitions could be categorized in the same model tree 1670. If a user wishes to define a particular reservoir model definition upon which a simulation could be based, the user can define an entirely new reservoir model definition or can populate the reservoir model definition using elements contained in other reservoir model definitions (e.g., by dragging and dropping elements from other reservoir model definitions in model tree 1670). Thus, for example, if a user wanted to run a simulation on a reservoir model having a zone boundary corresponding to "reservoir boundary 1," the user could drag element 1665 from one reservoir model definition to another in model tree 1670. In this example, after being dragged and dropped, the user will see element 1675 copied in another reservoir model definition. The user can similarly drag and drop other elements different reservoir model definitions to fully define additional reservoir model definition. This allows the user to use the elements contained in one reservoir model definition as the basic building blocks for other reservoir model definitions.

In addition to displaying reservoir model definitions, graphical user interface 135 can display simulation run definition. In model tree 1670, various simulation run definitions for modeling a reservoir can be displayed. In one embodiment of the present invention, the user can define a simulation run by dragging and dropping elements from one simulation run definition into another. In this manner, the user can use various reservoir model definitions and simulation run definitions to define other reservoir model definitions and simulation run definitions. This can be done simply by dragging and dropping elements from one reservoir model definition or simulation run definition into another without having to actually re-enter data.

Once a simulation run definition has been defined, modeler program 150 can model the reservoir and return a set of results, which can be displayed in simulation window 1620 (e.g., element 1683). Additionally, the results can be archived, with the last set of results displayed in results window 1684. The results can then be dragged into display window 1640 and be shown in various formats, including a two-dimensional model, a three-dimensional model, or charts and graphs displaying various properties of the modeled reservoir.

In addition to displaying the results returned by modeler program 150, display window 1640 can include a 2-D editor 1690. As will be discussed below, the user can use 2-D editor 1690 to define various elements for the reservoir model definitions displayed in model tree 1670. Display window 1640 can also include a 3-D viewer 1692. In one embodiment of the present invention, the user can drag a reservoir model definition into the 3-D viewer, and the 3-D viewer will display a three-dimensional view of the reservoir model. This can aid the user in visualizing the model and in correcting errors in the reservoir model definition. Additionally, display window 1640 can also include a chart viewer 1694 which can be used to display various charts and graphs related to the reservoir model definition, the simulation run definition, or the results returned by the modeler program. The display in chart viewer 1694 can be prompted by the user clicking on a set of results displayed in model tree 1670.

As can be easily understood from the above discussion, graphical user interface 135 provides an easy, user-friendly interface for users to provide a reservoir model definition and to display the results of modeling a reservoir. Because graphical user interface 135 can include drag-and-drop functionality, a user can easily build new reservoir model definitions from extant elements from a previously defined model and,

likewise, can easily build new simulation runs from various reservoir model definitions or elements in the model tree. Thus, the user can easily create several reservoir model definitions and multiple simulation runs without having to enter new data. Furthermore, graphical user interface 135 can provide an aesthetic and well-organized system for displaying data related to the modeling of a reservoir.

To better aid in an understanding of the ease and simplicity of the present invention for defining and displaying a reservoir model, FIGUREs 17-22C illustrate screen shots of one embodiment of graphical user interface 135 during various stages of a user defining and displaying the reservoir model definition and the results of a simulation run.

In one embodiment of the present invention, when a user is interested in creating a new project, the user can click on the file menu on the menu toolbar 1650 and then click on "new" in the file pull-down menu. This functionality should be familiar to any computer user who has created a new document in common word processing applications such as Microsoft Word. After a user has clicked on the file and new options as previous described, the user can be given an option of naming his project and giving the project a directory location where the project file can be kept. In addition to naming the project, the user can be given the option in a dialog box (not shown) to select an appropriate physics module through a series of simple questions about the reservoir model and customize the module's global constraints if necessary. Physics modules can be used to define the internal physics of a reservoir and can include, for example, one phase gas 3D, one phase gas 4D, two phase 3D, etc.

FIGURE 17 illustrates a screen shot of one embodiment of graphical user interface 135 according to the present invention after the user has opened a new project and selected a name for the project. When the new project is created, window 1620 (e.g., the combined reservoir model definition window and simulation run definition window) can be initialized without any data. As can be seen in FIGURE 17, model tree 1670 is empty (e.g. none of the elements in model tree 1670 have been populated with data). Thus, an empty model can be created and the user can subsequently be automatically lead through the steps necessary to define the model. To begin defining a reservoir model definition, 2-D editor 1690 can automatically be displayed in display window 240.

FIGURE 18 shows a screen shot of one embodiment of graphical user interface 135 according to the present invention with 2-D editor 1690 displayed in display window

1640. Using 2-D editor 1690, the user can create, edit, and display zone boundaries. Similar to other computer drawing tools, the user will be able to create poly-lines, by simply clicking on points in 2-D editor 1690. Alternatively, the user can create zone boundaries (e.g., boundaries for the reservoir) using ellipses, polygons, etc., or the user can load zone boundaries that are stored in a compatible file format such as a spreadsheet. When a user is finished defining a zone boundary, such as zone boundary 1801, a form or a pop-up dialog can prompt the user to name the new zone boundary. The name of the new zone boundary can then appear in graphical user interface 135 (e.g., element 1807 represents one zone or reservoir boundary). The user can then define additional zone boundaries for the reservoir model definition. Furthermore, the user could define a zone boundary in zone boundary fields 1811, which could be linked to 2-D editor 1690.

In addition to defining zone boundaries in 2-D editor 1690, the user can provide well definitions. In one embodiment of the present invention, when the user clicks on well element 1810 of model tree 1670, a context menu with a "create well" option could appear. After clicking on the "create well" option, a dialog box (not shown) could appear asking the user to input well properties, such as inner and outer radius of the well and other relevant information used by modeler program 150 to create a finite elements mesh around the well. The user can specify whether the well is an injector or a producer and name the well. The well can be displayed as an element under well element 1810 of model tree 1670. The user could then select the location of the well by placing an icon representing the well in the 2-D editor 1690 (e.g., well icon 1820).

From 2-D editor 1690, the user can also create, edit and display zone points. Zone points are points that will be honored during the automatic meshing process. The user can click zone points into existence by clicking on points in 2-D editor 1690. In one embodiment of the present invention, the user can toggle 2-D editor 1690 into showing the mesh that modeler program 150 will apply to the reservoir model. Furthermore, the user can instantaneously see a re-mesh as the user adds or removes zone points from 2-D editor 1690.

In addition to using 2-D editor 1690 to define zone boundaries, wells and zone points, a user can specify the reservoir properties at various points in the reservoir. From model tree 1670, the user can click on property maps element 1615 and select a "create property maps" option from a pop-up context menu. After selecting "create property

maps," a dialog box can prompt the user to name the new property map, as well as enter the units of the property being entered. The user could then click on points in 2-D editor 1690 to specify points associated with the new property map. For each point, the user can specify the property value for that point. Examples of reservoir properties that can be included in the property map include things such as permeability of the reservoir in the X direction, the porosity of the reservoir, or the thickness, etc. Thus, a user can define the porosity of the reservoir at different locations by clicking on various points in 2-D editor 1690 and assigning those points a porosity value. Alternatively, the user can assign constant porosity values to the reservoir (e.g., the reservoir could have a constant porosity throughout).

Along with defining zone boundaries, zone points, wells and property maps, the user can define zone layers (or reservoir layers) using graphical user interface 135. A reservoir layer corresponds to the depth and thickness of a particular zone in a reservoir. From model tree 1670, the user can click on flow unit element 1830 to call up a context menu. In the context menu, the user can select a "create reservoir layer" option, prompting a reservoir layer editor to appear in display window 1640. FIGURE 19 is a screen shot of one embodiment of reservoir layer editor 1900 according to the present invention. In reservoir layer editor 1900, the user can create reservoir layers and specify the base and top depths of each layer. The user can either define the layers in layer graphic 1910 by moving the depth bars 1920 up and down or can directly enter the layer depth in the fields provided. Additionally, the user can drag property maps from model tree 1670 onto the layers to associate the property maps with the layers. For example, if a property map had been previously created named "Property Map 1," and was stored under a property map element in model tree 1670, Property Map 1 could be dragged into layer editor 1900 and dropped into layer 2. This would associate Property Map 1 with layer 2. Alternatively, the user can also define zone layers by entering data in zone layer fields 1930.

A user can also define conditions for reservoir boundaries, wells and reservoir layers. The user can select the reservoir boundary, well or reservoir layer from model tree 1670 to display a pop-up context menu. From the pop-up context menu the user can select a "create condition" option to create a new condition set. A condition editor dialog box can appear in display window 1640 that allows the user to create outer boundary conditions, well conditions, initial conditions, and interior conditions and then

insert them into a selected condition set. FIGUREs 20A and 20B show screen shots of one embodiment of the condition editor dialog box according to the present invention. FIGURE 20A shows a dialog box for specifying initial conditions and boundary conditions, and FIGURE 20C shows a dialog box for specifying well conditions. As can be seen in each of these figures, a condition name field 2010 can be used to specify the conditions set to which a particular condition belongs. The name of the conditions set can appear in window 1620 under conditions set element 1830 (see FIGURE18).

In one embodiment of the present invention, the user can also define fluid properties. In response to the user clicking on the "create pvt items" option in a context pop-up menu, a pvt edit dialog box can appear. FIGURE 21 illustrates a screen shot of one embodiment of the pvt edit dialog box 2100 according to the present invention. In pvt edit dialog box 2100, the user can specify such rock and fluid properties for a reservoir such as the pressure, volume, temperature, relative permeability and the capillary pressure. When data has been entered in the fields in window 2110, the user can create charts, such as chart 2120, to visualize what was just entered.

From model tree 1670, the user can also create a simulation run definition (e.g., by clicking on element 1670 to call up simulation run dialog boxes. FIGUREs 22A through 22C show embodiments of screen shots for providing a simulation run definition. As can be seen in FIGURE 22A, at area 2200, the user can select time slices for a reservoir model definition. Similarly, as illustrated in FIGURE 22B, in display window 1640, the user can define a time frame for a simulation run. Additionally, as can be seen from FIGURE 22C, the user can define a set of solver parameters in display window 1640 (e.g., in solver parameters window 2240).

Returning again to FIGURE 16, FIGURE 16 illustrates one embodiment of the graphical user interface 135 according to the present invention, in which the model tree 1670 has been populated with data entered by a user. In one embodiment of the present invention, the data can be entered by the user in the manner described in conjunction with FIGUREs 16 through 22C.

In order to view the reservoir model that is defined by the reservoir model definition, the user can drag the reservoir model definition into the 3-D display window 1692. 3-D display window 1692 can be called up, for example, by the user clicking on the view option in menu toolbar 1650 and then clicking on a 3-D viewer option in the corresponding pull-down menu. In one embodiment of the present invention, by

dragging a reservoir model definition, such as the "reservoir 1" definition (e.g., element 1677) into 3-D viewer 1692, 3-D viewer 1692 will display a 3-D view of the reservoir defined by reservoir model definition 1. Furthermore, by dragging and dropping a different set of elements from model tree 1670, the user can define additional reservoir model definitions. On the other hand, the user could define additional reservoir model definitions by completely defining a new reservoir model definition (e.g., by repeating the steps discussed in conjunction with FIGUREs 16 through 22C). It should be noted that this process can be carried out by the user selecting elements from model tree 1670 to call up appropriate dialog boxes, by the user automatically being presented with the dialog boxes to walk the user through providing the definitions, or a combination of both. Similarly, the user could define multiple simulation run definitions by dragging elements from one simulation run definition in model tree 1670 and dropping them into another simulation run definition or be defining an entirely new simulation run definition.

After defining a simulation run definition, the user can run the simulation run by, for example, selecting a run option from a simulation run context menu. The selected simulation runs can then be processed by modeler program 150. Once a simulation run has been completed, the reservoir model, which was created by the simulation run, can be archived. For example, FIGURE 16 shows that reservoir 1 has been modeled and is archived under results element 1683 of model tree 1670. A user can then drag and drop the results into 3-D viewer 1692 to view the modeled reservoir.

In one embodiment of the present invention, the archived model can also be dragged and dropped into chart viewer 1694 of graphical user interface 135. Chart viewer 1694 can display charts and graphs that are pertinent to field engineers, such as formation volume factor versus pressure, viscosity versus pressure, solution gas ratio versus pressure, relative permeability versus saturation, or capillary pressure versus saturation. Additionally, chart viewer 1694 can provide well production time series plots which can give the user insight into the production of a given well over time. Examples of well production time series plots include production of phase rates, ratios, and cumulative phase volume charts. Furthermore, chart viewer 1694 can allow the user to display user defined charts so that the user can plot one property of a given reservoir against another property. In addition, a user can drag and drop multiple archived reservoir solutions into chart viewer 1694 so that the results from various reservoir

models can be directly compared by the user. To further aid in analysis of the archived model, the archived model can also be sliced with the predefined slice operations. Both time slices and well slices (e.g., slices of the reservoir model at some time t through the well) can be made by the user.

As can be understood from the foregoing discussion, the present invention can provide a user-friendly system and method for defining and displaying computer simulation models of reservoirs. The present invention can allow a user to define the basic building blocks for reservoir models and to then easily combine those building blocks into different reservoir models without having to re-enter large amounts of data. Additionally, the present invention can allow a user to define several sets of parameters for simulation run definitions and to then define multiple simulation run definitions using various sets of parameters and the different reservoir models defined by the user.

In one embodiment of the present invention, the defining of the reservoir model definitions and simulation run definitions can be done through a series of user-friendly dialog boxes and graphics tools. Furthermore, the reservoir model definition and simulation run definition can easily be defined by dragging and dropping various components of the respective definitions.

Because the actual modeling of the reservoir occurs in the background, a user does not need extensive knowledge of modeling techniques. Furthermore, the type of data entered is the type of data that would be generally known and understandable to petroleum engineers or workers out in the field, making the present invention exceptionally easy to use. Thus, the present invention provides substantial advantages over the prior art by allowing the user to define and display a computer simulation of a reservoir in a user-friendly manner. Furthermore, the present invention provides another advantage because the present invention allows the quick display of the type of information that is directly useful by reservoir engineers working in the field.

Although the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the invention as described in the appended claims.

WHAT IS CLAIMED IS:

1. A system for defining and displaying a reservoir model comprising a software program executable by a computer processor to provide a graphic user interface in a display device, wherein the graphic user interface is operable to:

display a series of windows walking a user through one or more steps to generate a reservoir model definition and a simulation run definition; and

display a set of results derived from the reservoir model definition and simulation run definition.

2. The system of Claim 1, wherein the series of windows includes a zone boundary definition window and wherein the user can define a zone boundary in the zone boundary definition window.

3. The system of Claim 2, wherein the zone boundary definition window comprises:

a 2-D editor; and

a set of zone boundary definition fields linked to the 2-D editor.

4. The system of Claim 1, wherein the series of windows includes a zone layer definition window, wherein the user can define a zone layer in the zone layer definition window.

5. The system of Claim 4, wherein the user can further define a set of zone layer properties in the zone layer definition window.

6. The system of Claim 5, wherein the set of zone layer properties comprises:

thickness;

permeability in the x direction;

permeability in the y direction; and

porosity.

7. The system of Claim 5, wherein the zone layer definition window, comprises:

a zone layer graphic; and

a zone layer property area.

8. The system of Claim 1, wherein the series of windows includes a well definition window, wherein in the user can define a well in the well definition window.

9. The system of Claim 8, wherein the well definition window comprises:

a 2-D editor, wherein the user can select the placement of the well in the 2-D editor; and

a well properties area, wherein the user can define a well type, a well inclination, and a well radius.

10. The system of Claim 1, wherein the series of windows includes a fluid properties window and wherein the user can define a set of fluid properties in the fluid properties window.

11. The system of Claim 10, wherein the fluid properties window comprises:

a fluid properties area; and

a chart viewer operable to graphically display the set of fluid properties.

12. The system of Claim 10, wherein the set of fluid properties includes:

an initial reservoir pressure;

a reservoir temperature;

a separator gas gravity; and

a condensate gravity.

13. The system of Claim 1, wherein the series of windows includes a well conditions window and wherein the user can define a set of well conditions in the well conditions window.

14. The system of Claim 13, wherein the well conditions window includes:

a constrain definition area wherein the user can define the set of well conditions; and

a chart viewer operable to graphically display the set of well conditions.

15. The system of Claim 14, wherein the set of well conditions includes a production rate.

16. The system of Claim 1, wherein the series of windows includes a model parameters window, wherein the user can define a set of model parameters in the model parameters window.

17. The system of Claim 16, wherein the set of model parameters includes:
a modeling run time frame;
a time slice; and
a selection of output charts.

18. The system of Claim 1, wherein the software program is stored on a computer readable medium.

19. A system for defining and displaying a reservoir model, comprising a software program executable by a computer processor to:
display and graphically organize a set of project data;
display and graphically organize a reservoir model definition, wherein the reservoir model definition comprises a first set of elements from the set of project data;
display and graphically organize simulation run definition, wherein the simulation run definition comprises a second set of elements from the set of project data and the reservoir model definition; and
display and graphically organize the set of results.

20. The system of Claim 19, wherein the user defines the reservoir model definition in the graphical user interface by dragging the first set of elements from the set of project data and dropping the first set of elements into the reservoir model definition.

21. The system of Claim 19, wherein the user defines the simulation run definition in the graphical user interface by:
dragging the reservoir model definition and dropping the reservoir model definition into the simulation run definition; and

dragging the second set of elements from the set of project data and dropping the second set of elements into the simulation run definition.

22. The system of Claim 19, wherein the graphical user interface is further operable to display a 2D editor.

23. The system of Claim 22, wherein the user defines a zone boundary and a zone point by clicking on a set of selected points in the 2D editor.

24. The system of Claim 22, wherein the user defines a well placement by positioning a well icon in the 2D editor.

25. The system of Claim 19, wherein the graphical user interface is further operable to display a 3D viewer.

26. The system of Claim 25, wherein the 3D viewer is operable to display a 3D view of a reservoir model and wherein the 3D view of the reservoir model is prompted by the user dragging and dropping the reservoir model definition into the 3D viewer.

27. The system of Claim 25, wherein the 3D viewer is operable to display a 3D view based on the set of results, and wherein the 3D view based on the set of results is prompted by the user dragging and dropping the set of results into the 3D viewer.

28. The system of Claim 19, wherein the graphical user interface is further operable to display a chart viewer.

29. The system of Claim 28, wherein the chart viewer is operable to provide a display of a chart detailing the set of results and wherein the display of the chart is prompted by the user dragging and dropping the set of results into the chart viewer.

30. The system of Claim 19, wherein the software program is stored on a computer readable medium.

31. A method for defining and displaying a reservoir model comprising: presenting in a graphical user interface a series of windows walking a user through one or more steps necessary to generate a reservoir model definition and a simulation run definition; and

presenting in the graphical user interface a set of results derived from the reservoir model definition and simulation run definition.

32. The method of Claim 31, further comprising presenting in a graphical user interface the user with a zone boundary definition window, wherein the user can define a zone boundary in the zone boundary definition window.

33. The method of Claim 31, further comprising presenting in a graphical user interface a zone layer definition window, wherein the user can define a zone layer in the zone layer definition window.

34. The system of Claim 33, wherein the user can define a set of zone layer properties in the zone layer definition window.

35. The method of Claim 31, further comprising presenting in a graphical user interface a well definition window, wherein in the user can define a well in the well definition window.

36. The method of Claim 31, further comprising presenting in a graphical user interface a fluid properties window and wherein the user can define a set of fluid properties in the fluid properties window.

37. The method of Claim 31, further comprising presenting in a graphical user interface a well conditions window and wherein the user can define a set of well conditions in the well conditions window.

38. The method of Claim 31, further comprising presenting in a graphical user interface a model parameters window, wherein the user can define a set of model parameters in the model parameters window.

39. The method of Claim 31, further comprising:

(a) presenting in a graphical user interface a zone boundary definition window;

(b) presenting in a graphical user interface a zone layer definition window;

(c) presenting in a graphical user interface a well definition window;

(d) presenting in a graphical user interface a fluid properties window;

(e) presenting in a graphical user interface a reservoir conditions window; and

(f) repeating steps (a)-(e) for each reservoir model definition.

40. A method for defining a reservoir model comprising:

entering a zone boundary definition in a graphical user interface;

entering a zone layer definition in the graphical user interface;

entering a well definition in the graphical user interface;

entering a set of fluid properties in the graphical user interface;

entering a set of reservoir conditions in the graphical user interface; and

entering a set of model parameters in the graphical user interface.

41. The method of Claim 40, wherein:

the graphical user interface comprises a zone boundary definition window further comprising a 2-D editor; and

wherein the step of entering the zone boundary definition further comprises clicking on points in the 2-D editor.

42. The method of Claim 40, wherein:

the graphical user interface comprises zone layer definition window further comprising a zone layer graphic and a zone layer properties area; and

wherein the step of entering the zone layer definition further comprises providing a thickness for the zone layer definition by adjusting depth bars in the zone layer graphic.

43. The method of Claim 42, wherein the step of entering the zone layer definition further comprises entering a set of zone layer properties in the zone layer properties area.

44. The method of Claim 43, wherein the set of zone layer properties further comprises:
permeability in the x direction;
permeability in the y direction;
thickness; and
porosity.

45. The method of Claim 40, wherein:
the graphical user interface comprises a well definition window further comprising:
a 2-D editor; and
a well properties area; and
wherein the step of entering the well definition further comprises:
selecting the placement of a well in the 2-D editor; and
defining a well type, well inclination and well radius in the well properties area.

46. The method of Claim 40, wherein:
the graphical user interface comprises a fluid properties window further comprising:
a fluid properties area; and
a chart viewer operable to graphically display the set of fluid properties; and
wherein the step of entering a set of fluid properties further comprises:
entering an initial reservoir pressure;
entering a reservoir temperature;
entering a separator gas gravity; and
entering a condensate gravity.

47. The method of Claim 40, wherein:
the graphical user interface further comprises a reservoir conditions window further comprising:
a constraint definition area; and
a chart viewer operable to graphically display the set of reservoir conditions; and
wherein the step of entering a set of well conditions further comprises entering the set of well conditions in the constraint definition area.

48. The method of Claim 40, wherein:

the graphical user interface further comprises a model parameters window; and wherein the step of entering a set of model parameters further comprises:

entering a modeling run time frame;

a time slice; and

a selection of out put charts.

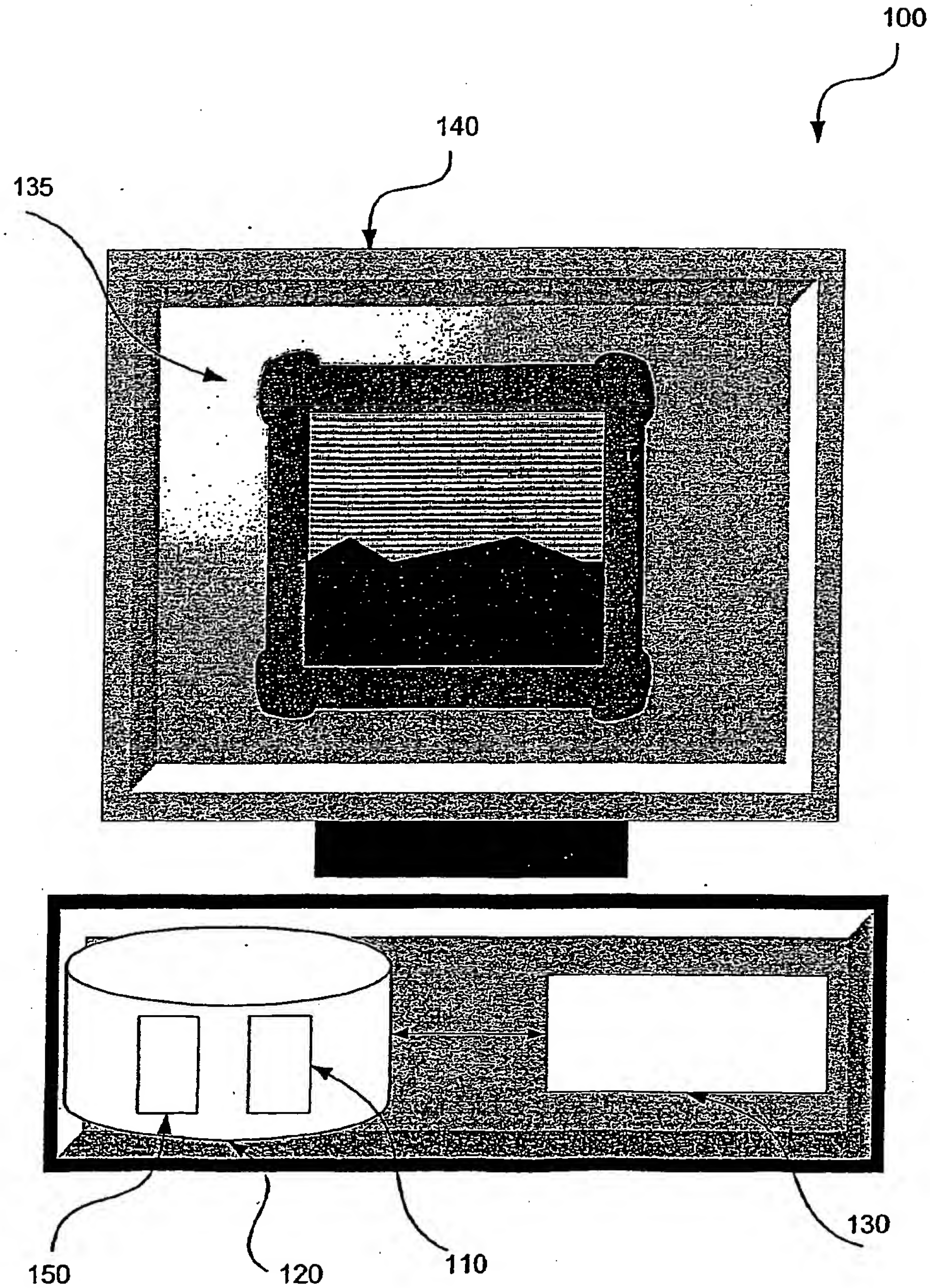


FIGURE 1

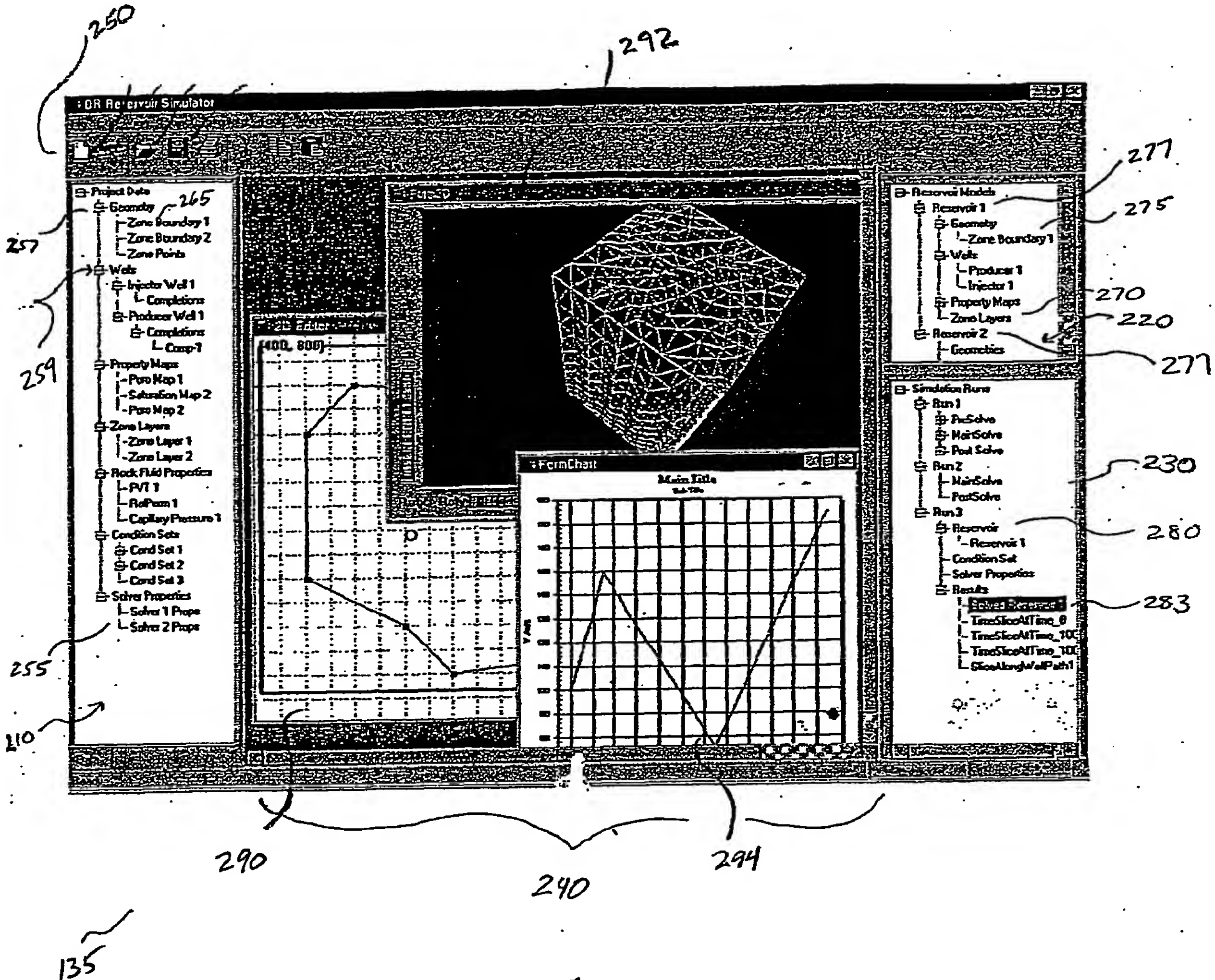

250
292
257
265
259
255
210
277
275
270
220
230
280
283
290
240
294
135
OR Reservoir Simulator
Project Data
Geometry
Zone Boundary 1
Zone Boundary 2
Zone Points
Wells
Injector Well 1
Completions
Producer Well 1
Property Maps
Poro Map 1
Saturation Map 2
Poro Map 2
Zone Layers
Zone Layer 1
Zone Layer 2
Rock Fluid Properties
PVT 1
RelPerm 1
Capillary Pressure 1
Condition Sets
Cond Set 1
Cond Set 2
Cond Set 3
Solver Properties
Solver 1 Props
Solver 2 Props
(400, 800)
FormChart
Main Title
Reservoir Models
Reservoir 1
Geometry
Zone Boundary 1
Wells
Producer 1
Injector 1
Property Maps
Zone Layers
Reservoir 2
Geometries
Simulation Runs
Run 1
PreSolve
MainSolve
Post Solve
Run 2
MainSolve
PostSolve
Run 3
Reservoir
Reservoir 1
Condition Set
Solver Properties
Results
TimeSliceAtTime_0
SliceAlongWellPath1

FIGURE 2

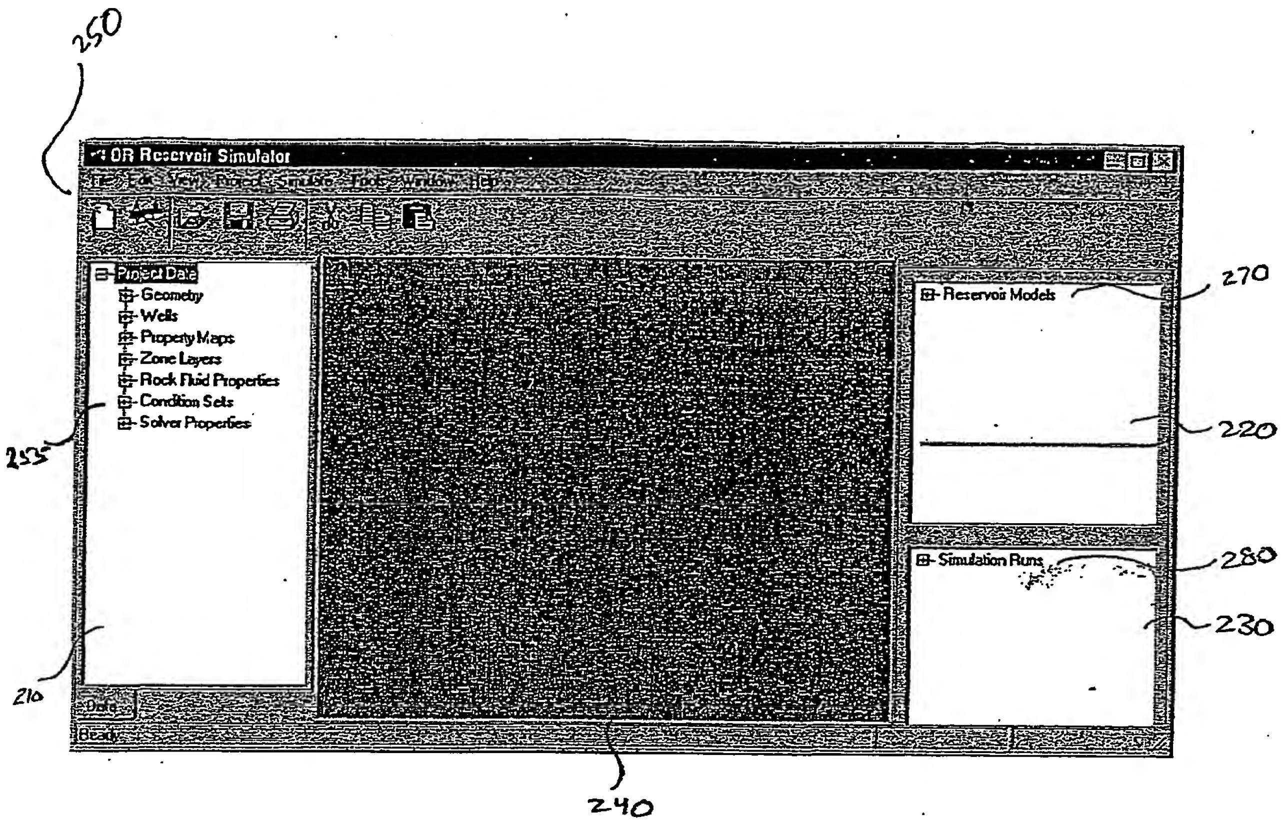

250
OR Reservoir Simulator
File Edit View Project Simulate Tools Window Help
Project Data
Geometry
Wells
Property Maps
Zone Layers
Rock Fluid Properties
Condition Sets
Solver Properties
255
210
Data
Ready
Reservoir Models
270
220
Simulation Runs
280
230
240

FIG 3

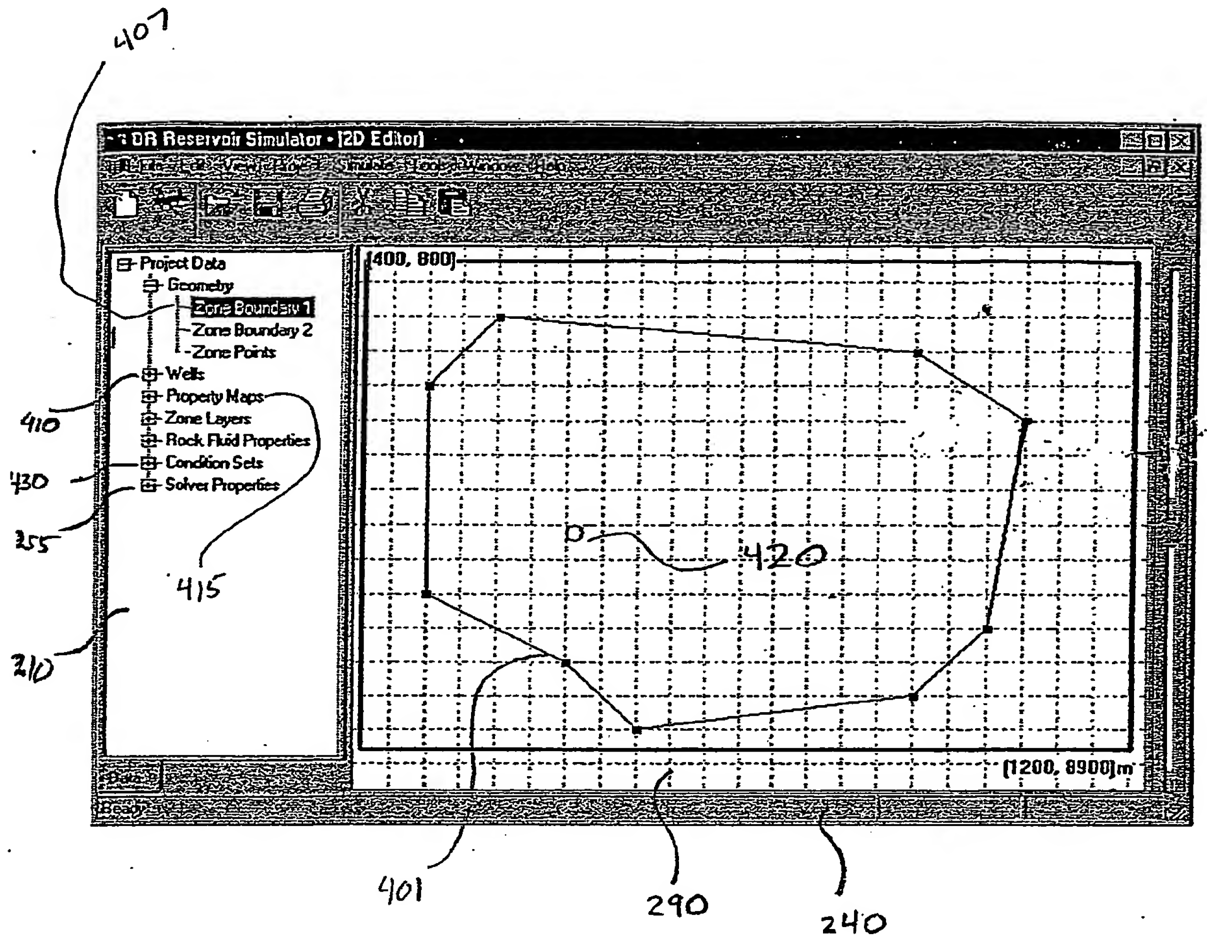

407
DR Reservoir Simulator - [2D Editor]
Project Data
Geometry
Zone Boundary 1
Zone Boundary 2
Zone Points
Wells
Property Maps
Zone Layers
Rock Fluid Properties
Condition Sets
Solver Properties
[400, 800]
420
[1200, 8900]m
Ready
410
430
355
415
210
401
290
240

FIG 4

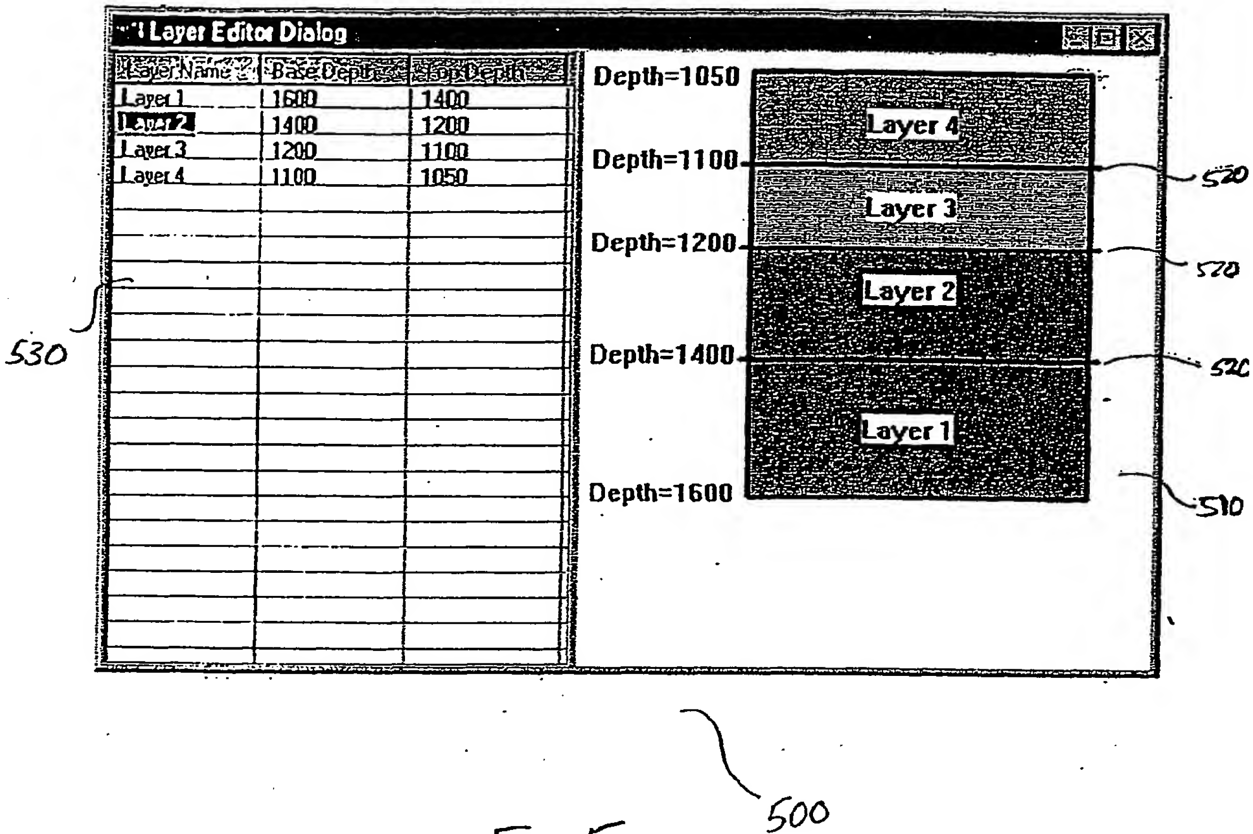
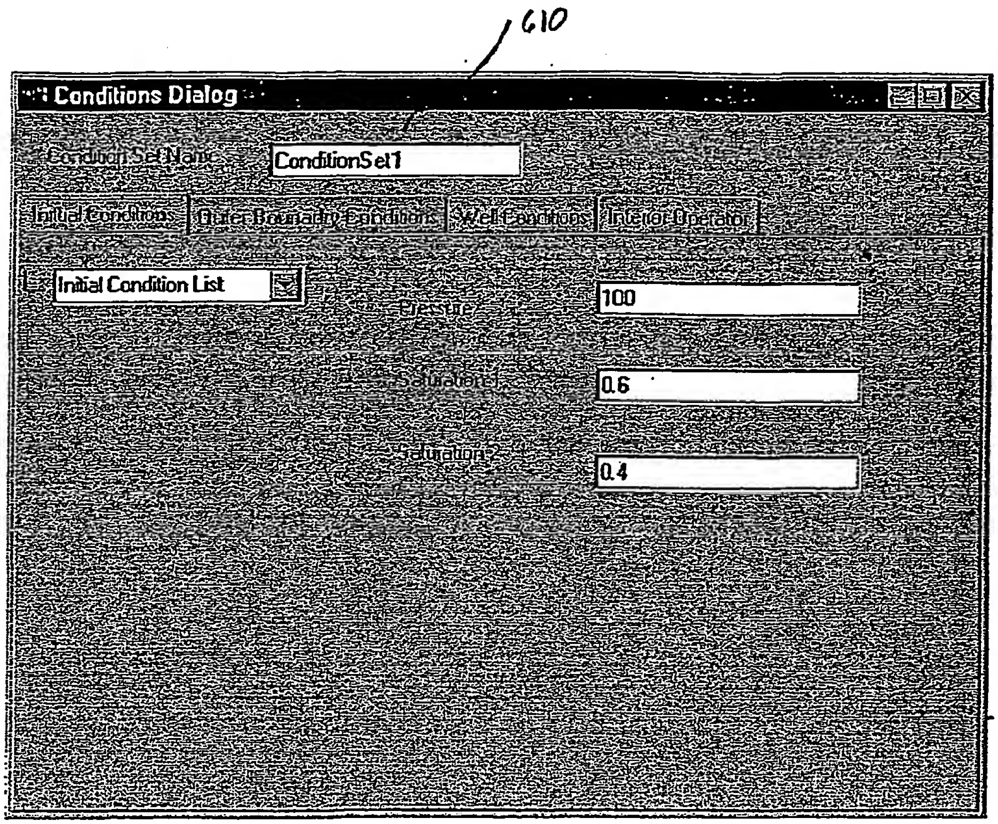

Layer Editor Dialog
Layer Name
Base Depth
Top Depth
Layer 1
1600
1400
Layer 2
1400
1200
Layer 3
1200
1100
Layer 4
1100
1050
Depth=1050
Layer 4
Depth=1100
520
Layer 3
Depth=1200
520
Layer 2
Depth=1400
520
Layer 1
Depth=1600
510
530
500

Fig 5


610
Conditions Dialog
Condition Set Name
ConditionSet1
Initial Conditions
Outer Boundary Conditions
Well Conditions
Interior Operator
Initial Condition List
Pressure
100
Saturation1
0.6
Saturation2
0.4

135

FIG 6A

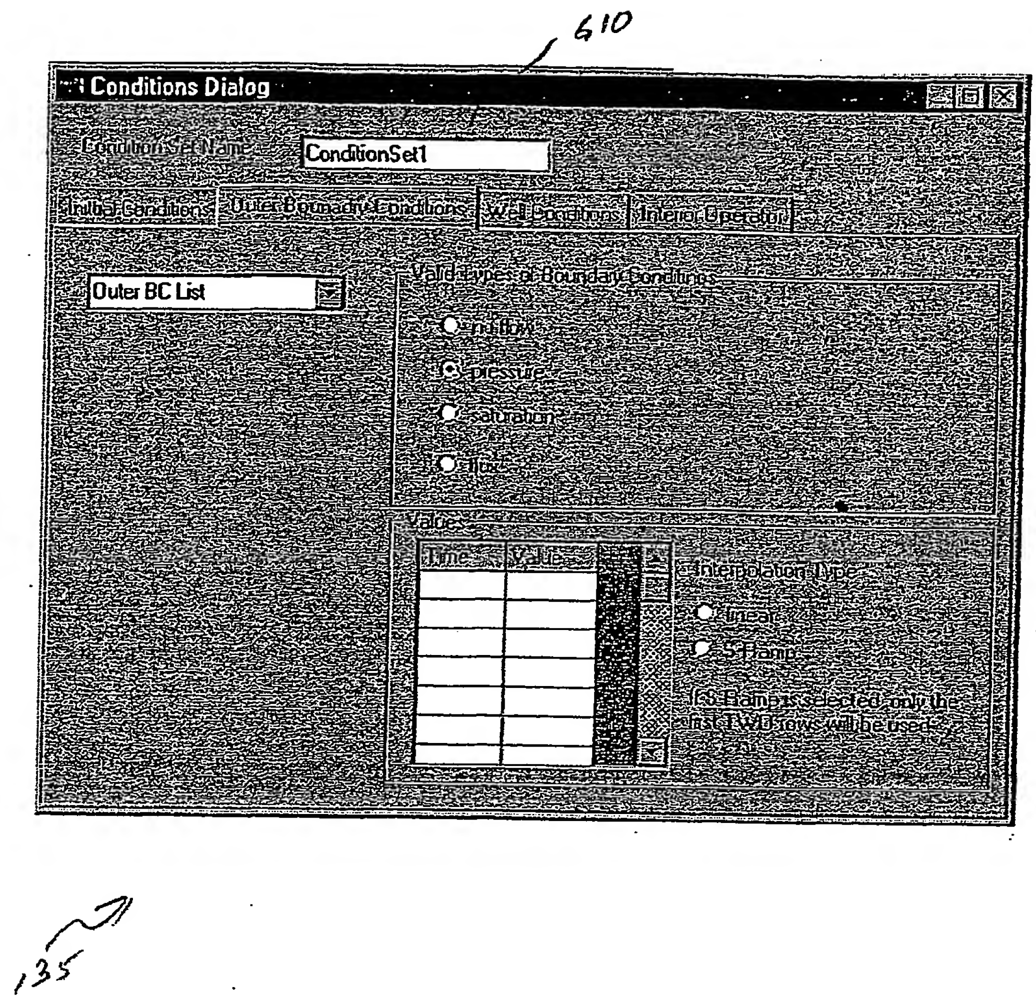
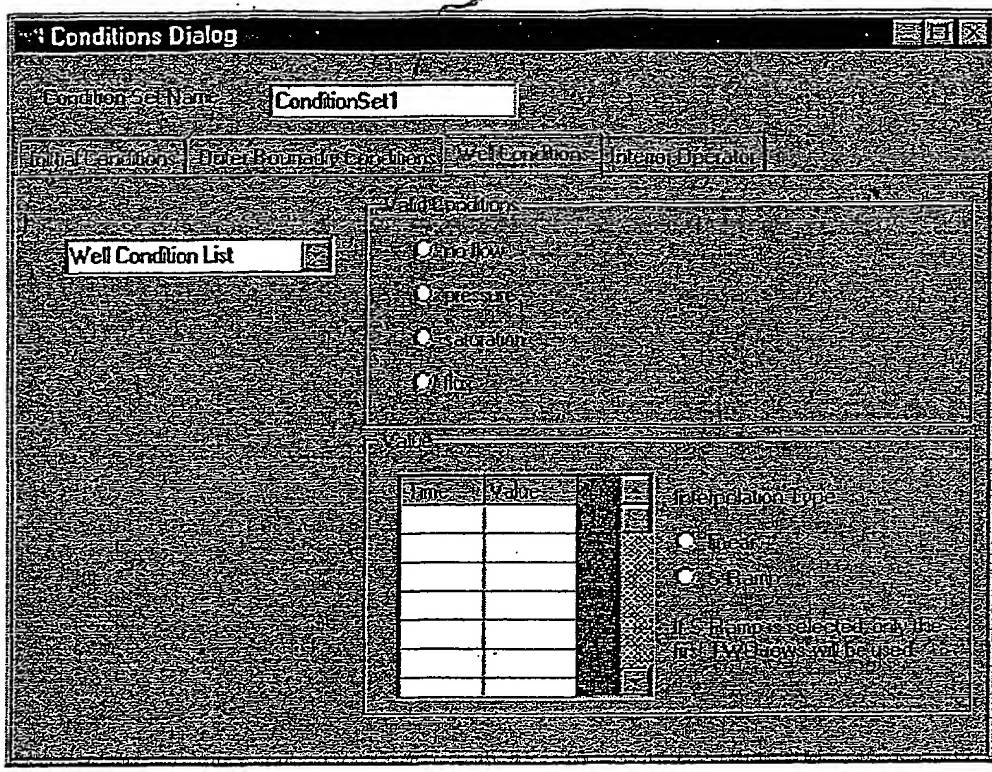

610
Conditions Dialog
Condition Set Name
ConditionSet1
Initial Conditions
Outer Boundary Conditions
Well Condition
Interior Operator
Outer BC List
Valid types of Boundary Conditions
no flow
pressure
saturation
flux
Value
Time
Value
Interpolation Type
linear
S Ramp
If S Ramp is selected, only the first TWO rows will be used.
135

FIG 6B

610



135

FIG 6C

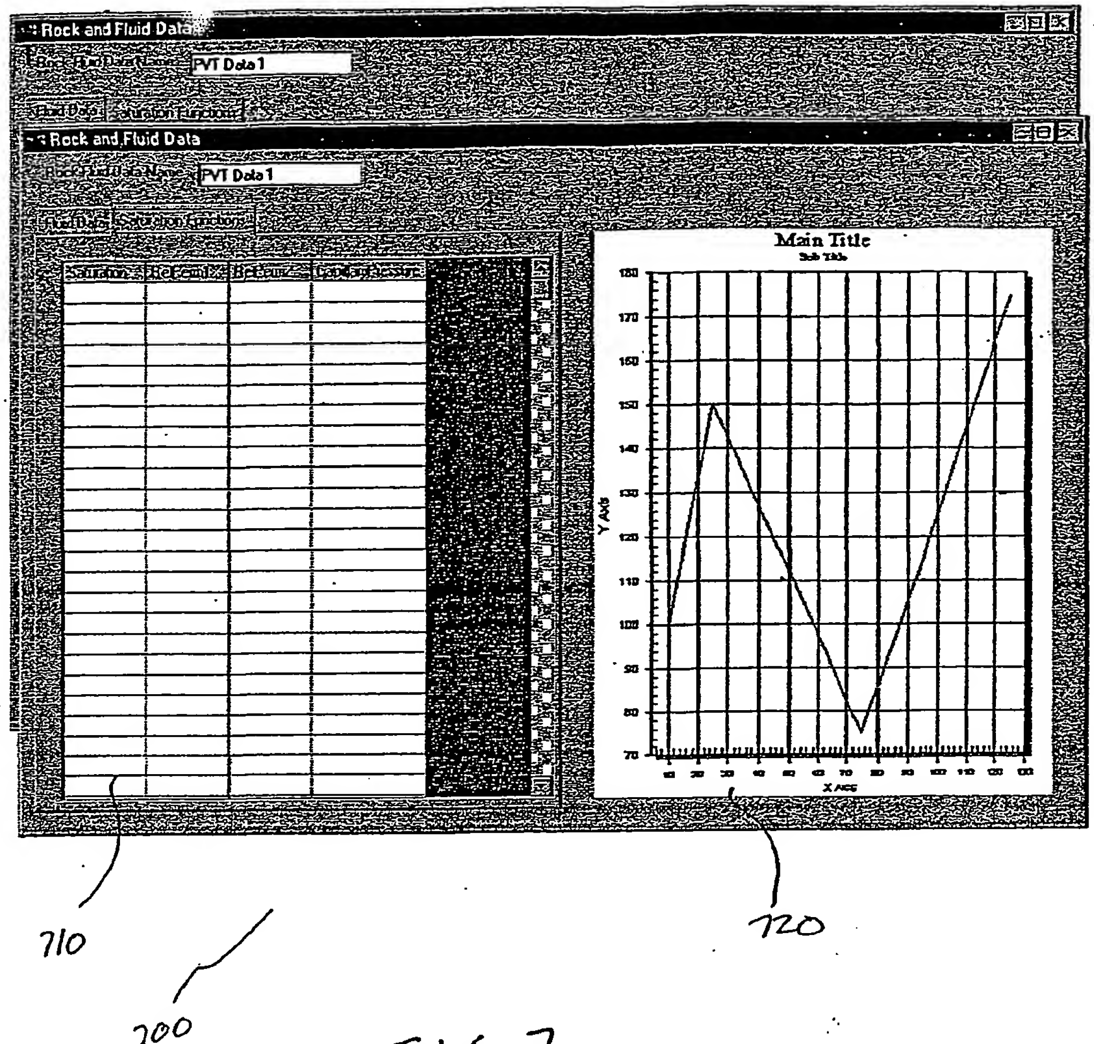

Rock and Fluid Data
PVT Data 1
Rock and Fluid Data
PVT Data 1
Main Title
Y Axis
X Axis
710
720
700

FIG 7

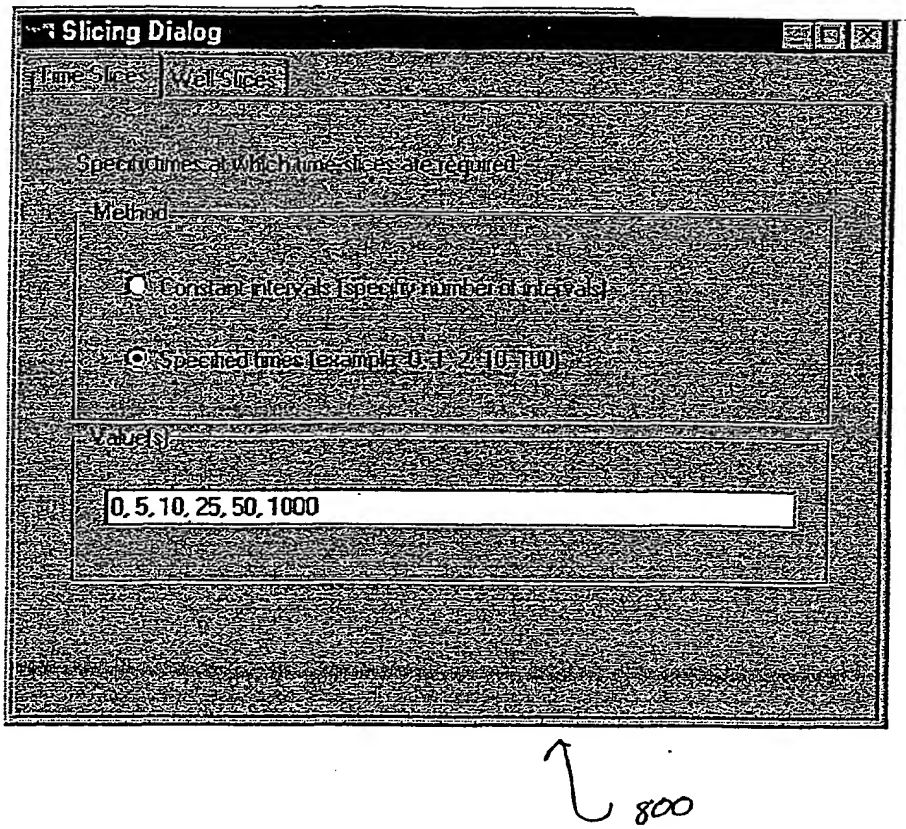

Slicing Dialog
Time Slices
Wall Slices
Specify times at which time slices are required
Method
Constant intervals [specify number of intervals]
Specified times [example: 0, 1, 2, 10, 100]
Value(s)
0, 5, 10, 25, 50, 1000
800

Fig 8

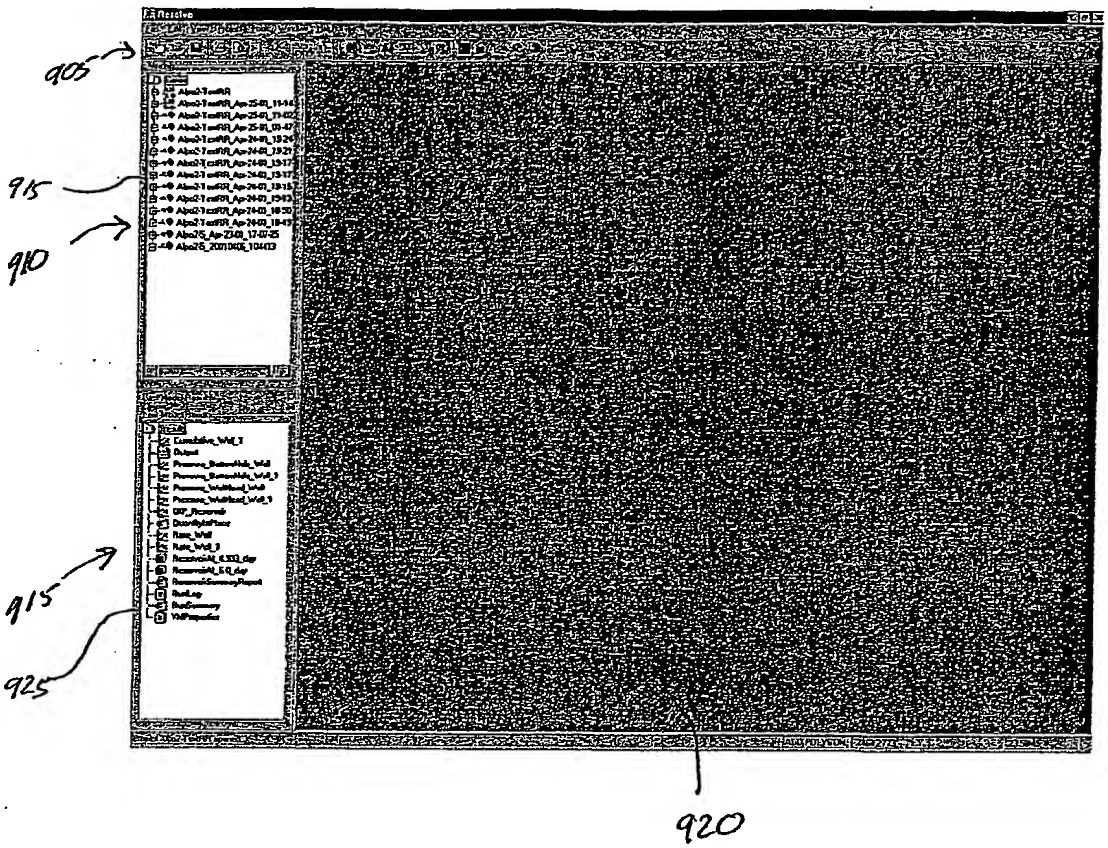


Fig 9

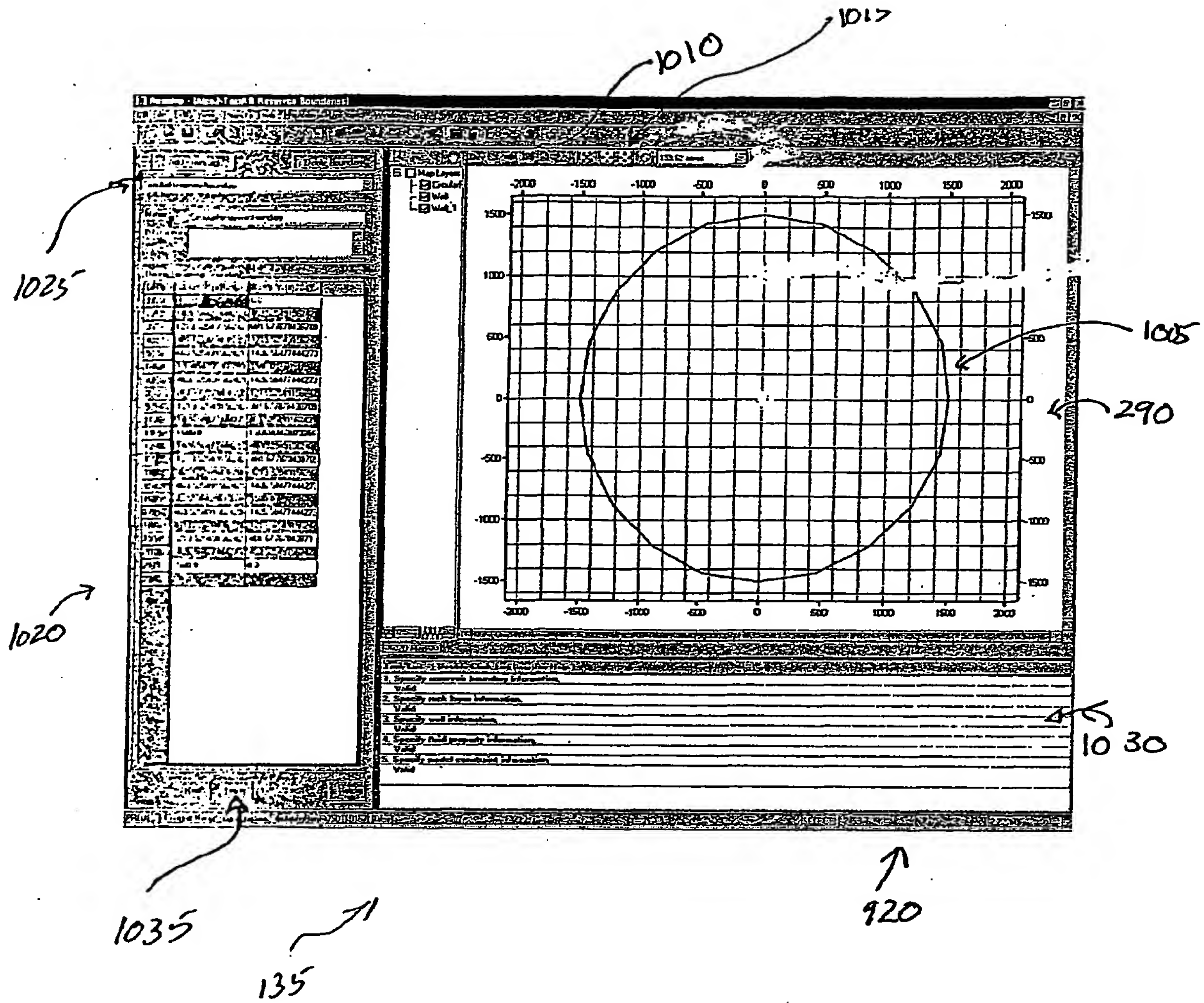


FIG 10

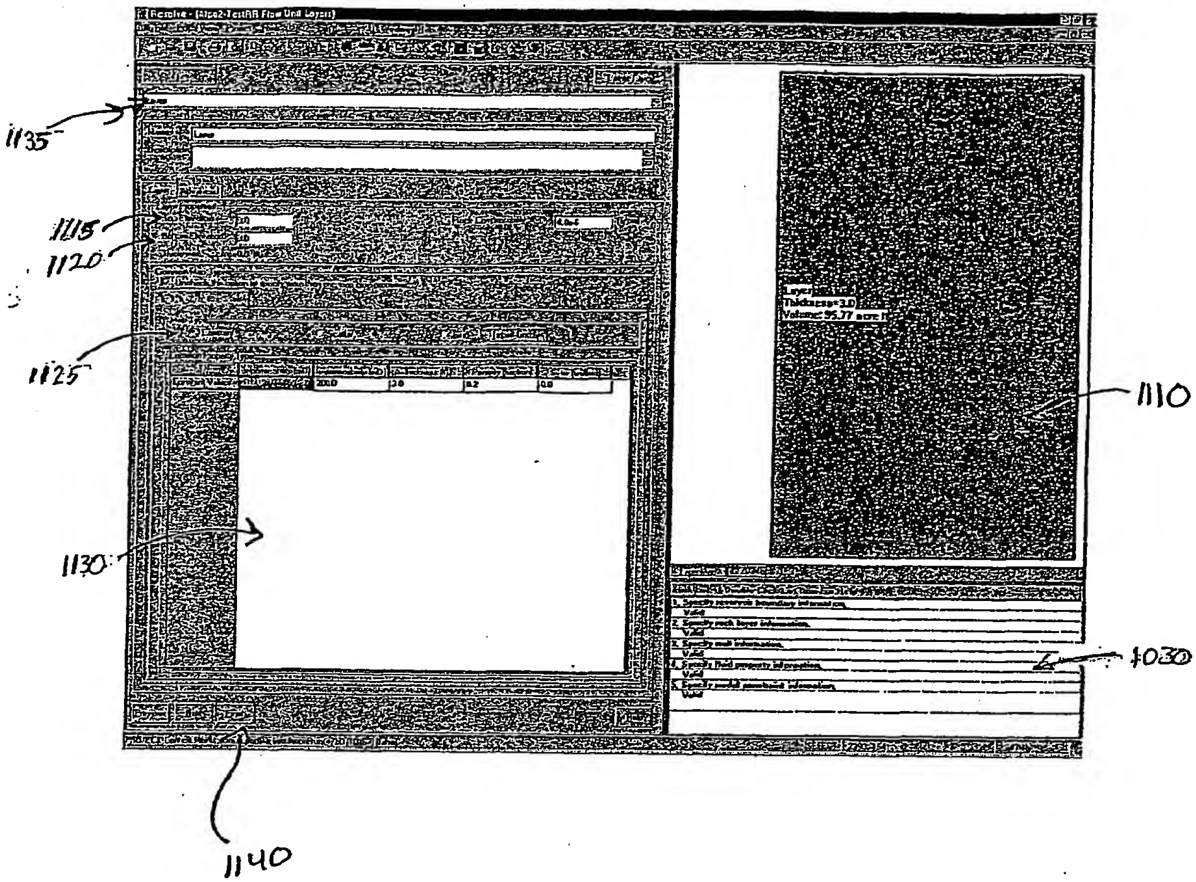

1135
1115
1120
1125
1130
1110
1030
1140
Layer
Thickness=3.0
Specify reservoir boundary information.
Specify rock layer information.
Specify well information.
Specify fluid property information.
Specify model parameter information.

FIG 11.

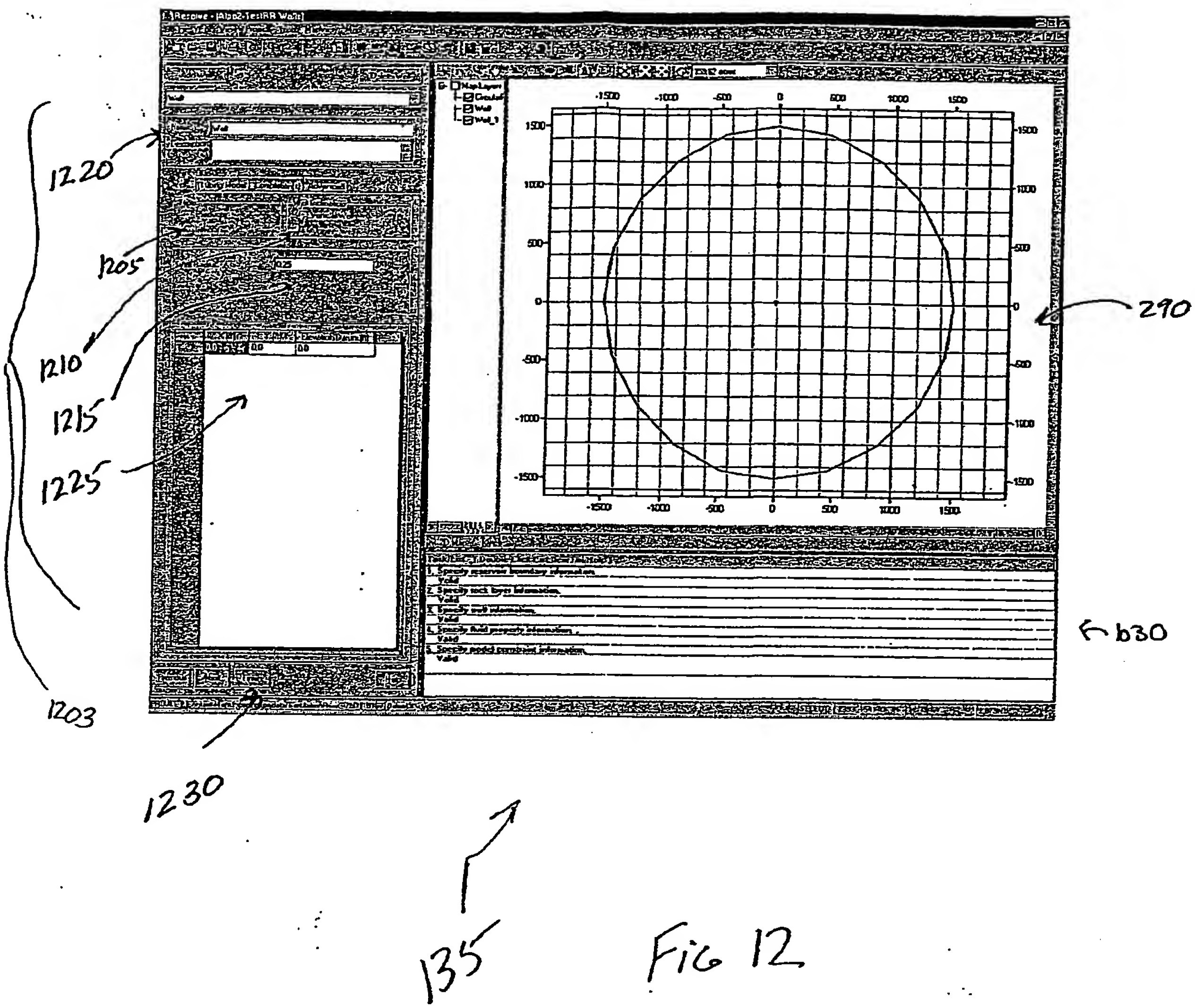

1220
1205
1210
1215
1225
1203
1230
290
630
135
1. Specify reservoir boundary information.
2. Specify rock layer information.
3. Specify well information.
4. Specify fluid property information.
5. Specify model constraint information.

Fig 12

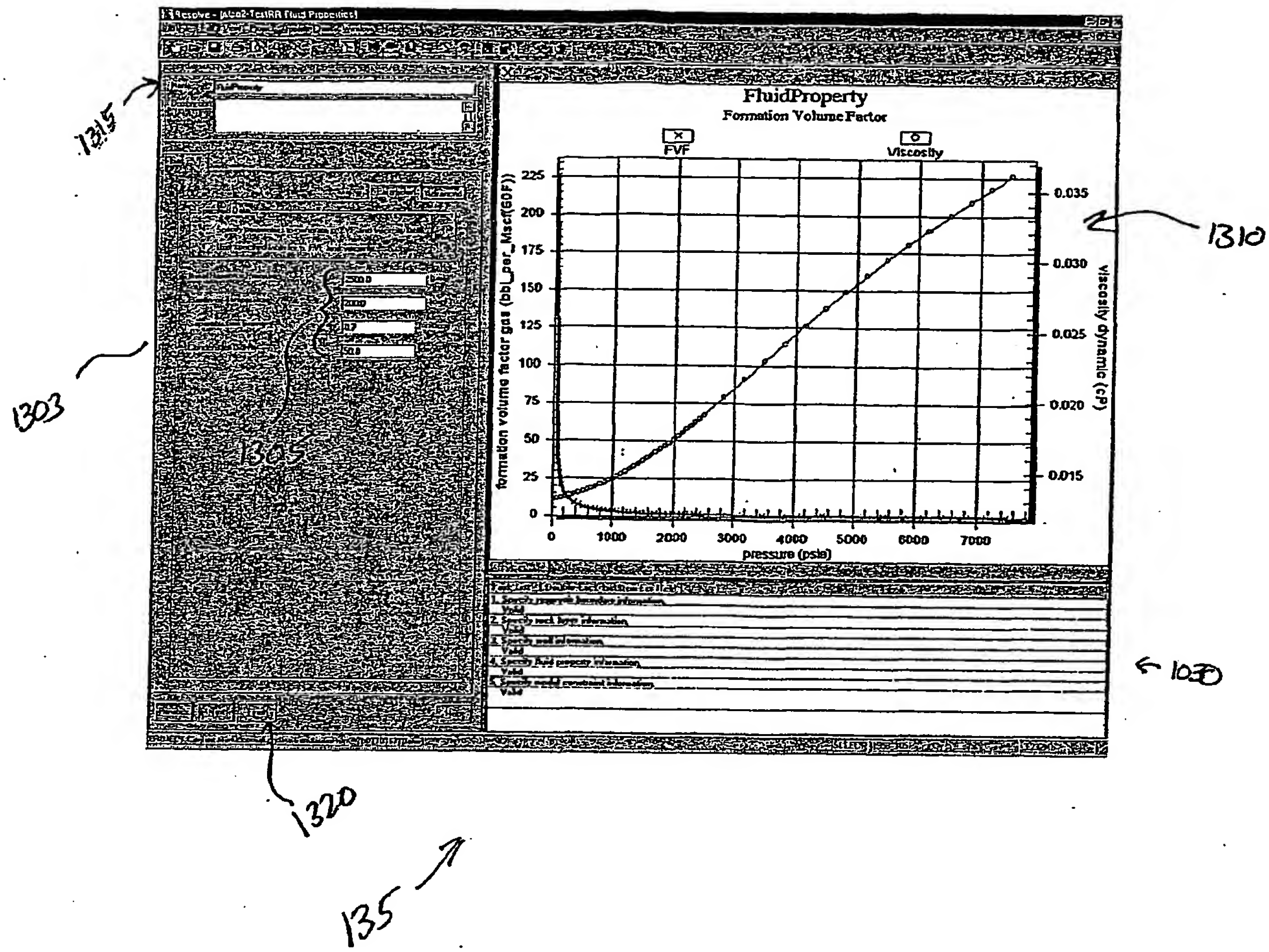

1315
1303
1305
1310
1030
1320
135
FluidProperty
Formation Volume Factor
FVF
Viscosity
formation volume factor gas (bbl_per_Mscf(GOF))
viscosity dynamic (cP)
pressure (psia)
0
25
50
75
100
125
150
175
200
225
0.015
0.020
0.025
0.030
0.035
1000
2000
3000
4000
5000
6000
7000

FIG 13

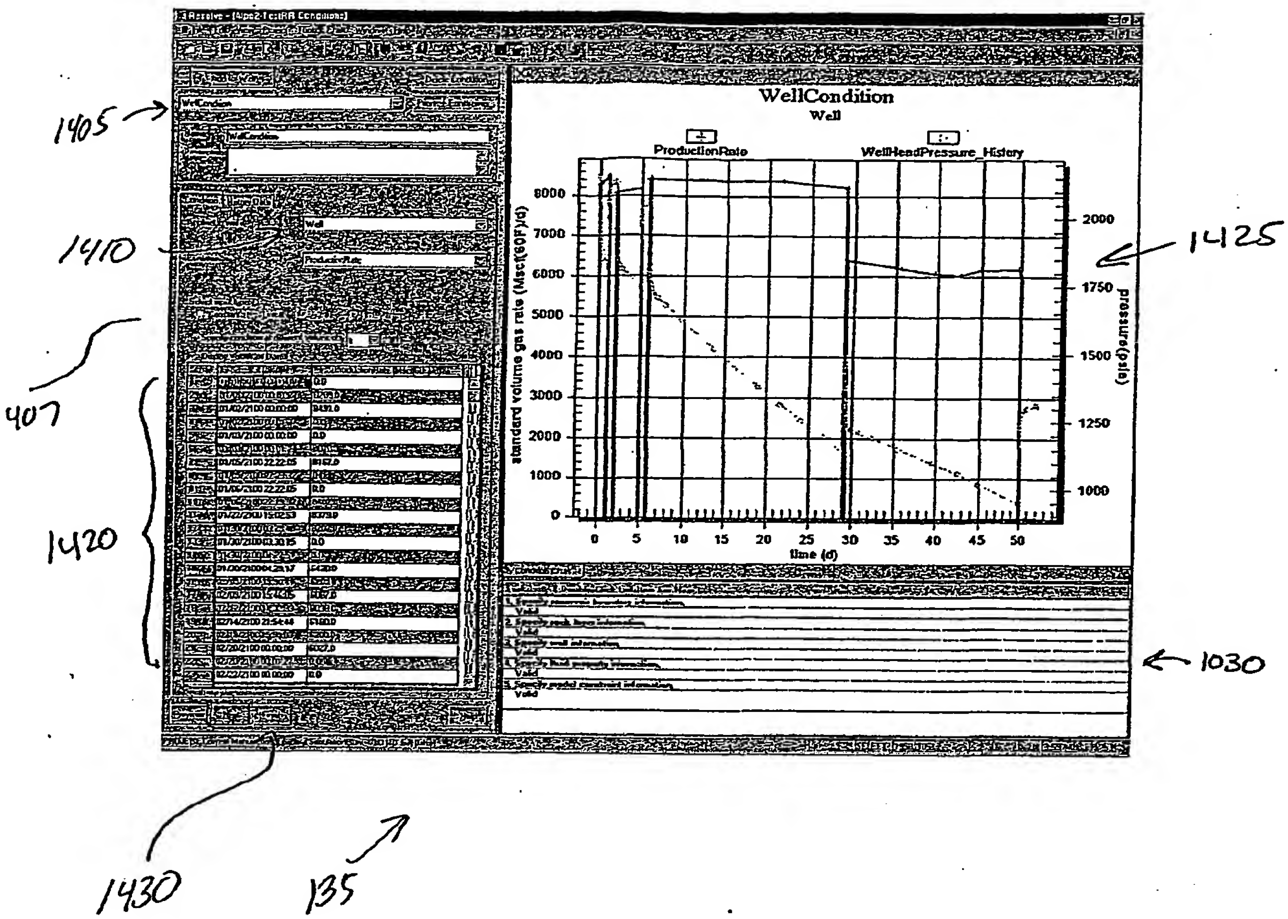

1405
1410
407
1420
1430
135
1425
1030
WellCondition
Well
ProductionRate
WellHeadPressure_History
standard volume gas rate (Mscf(60F)/d)
pressure (psia)
time (d)

Fig 14

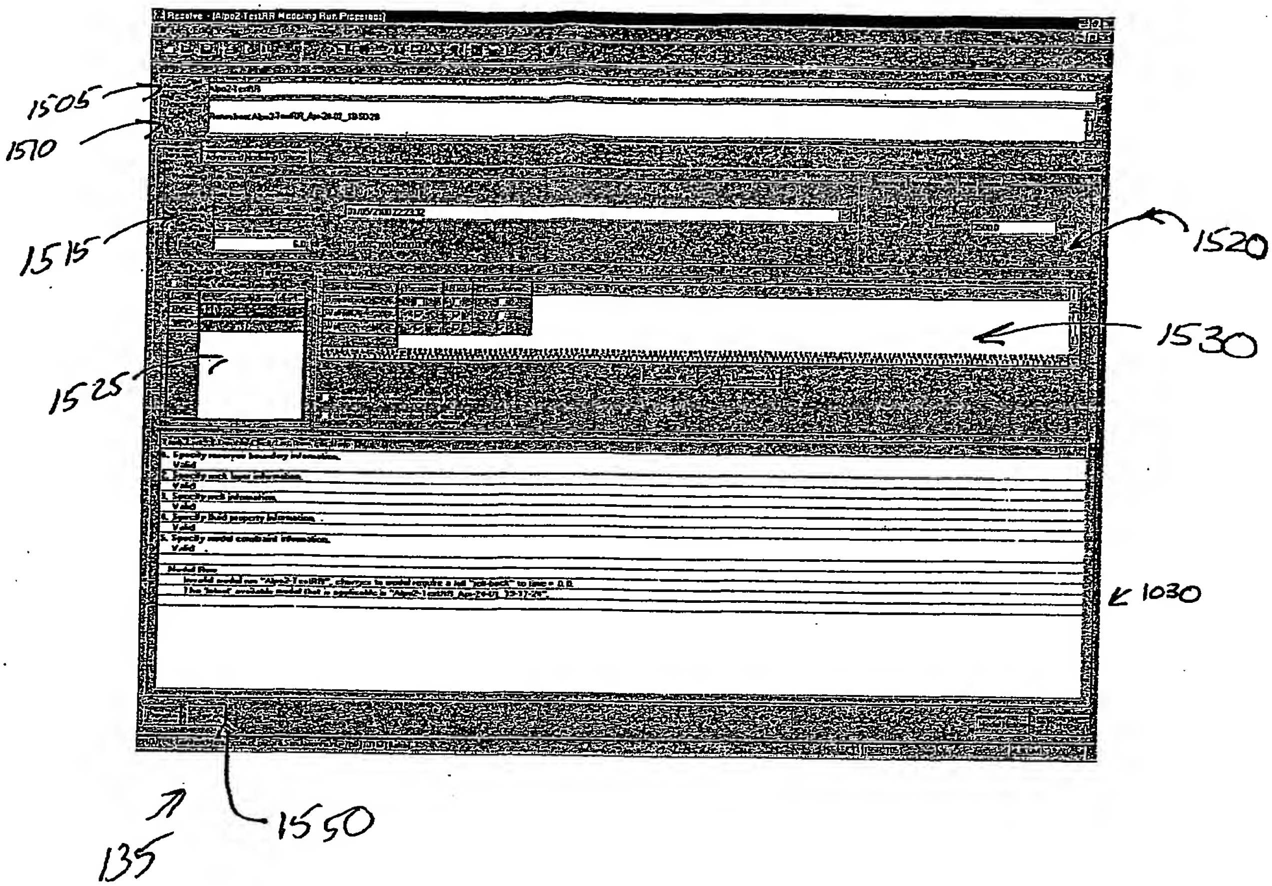
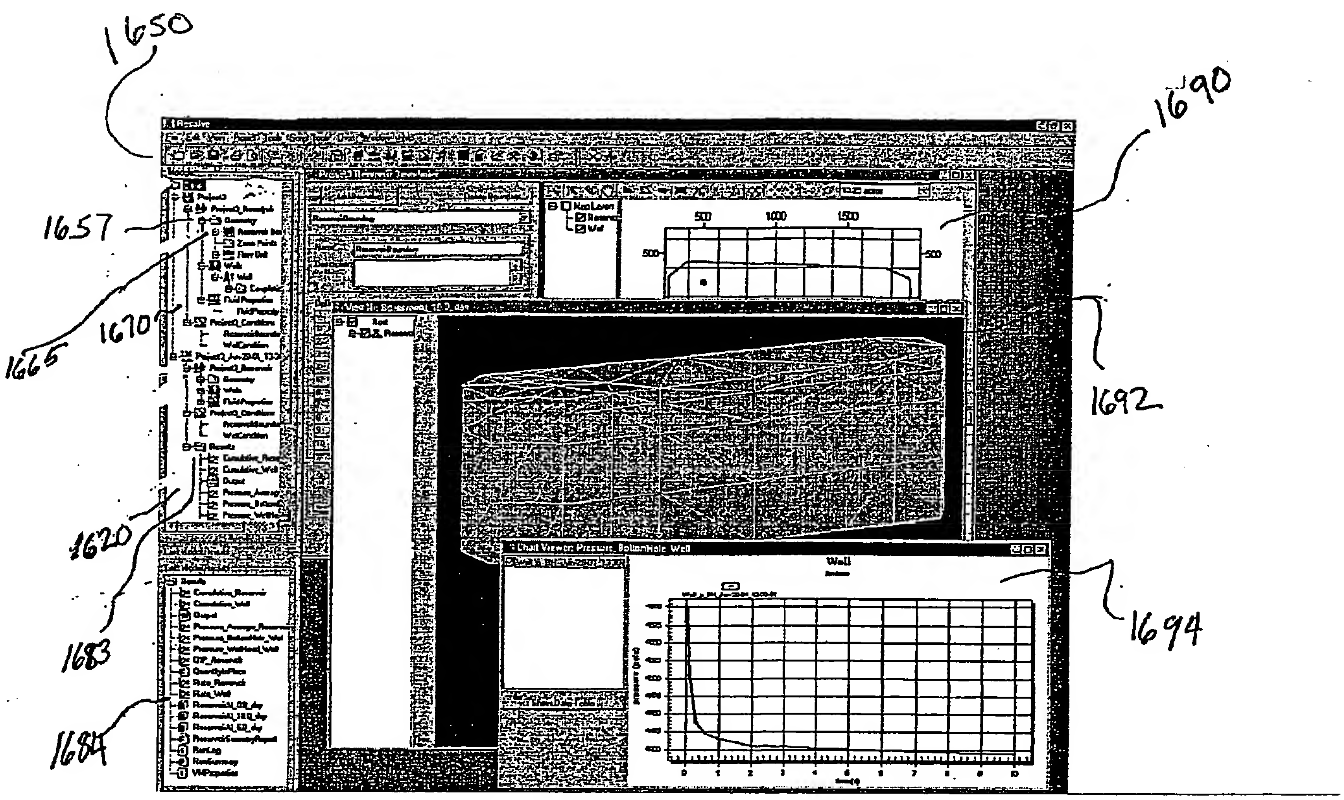
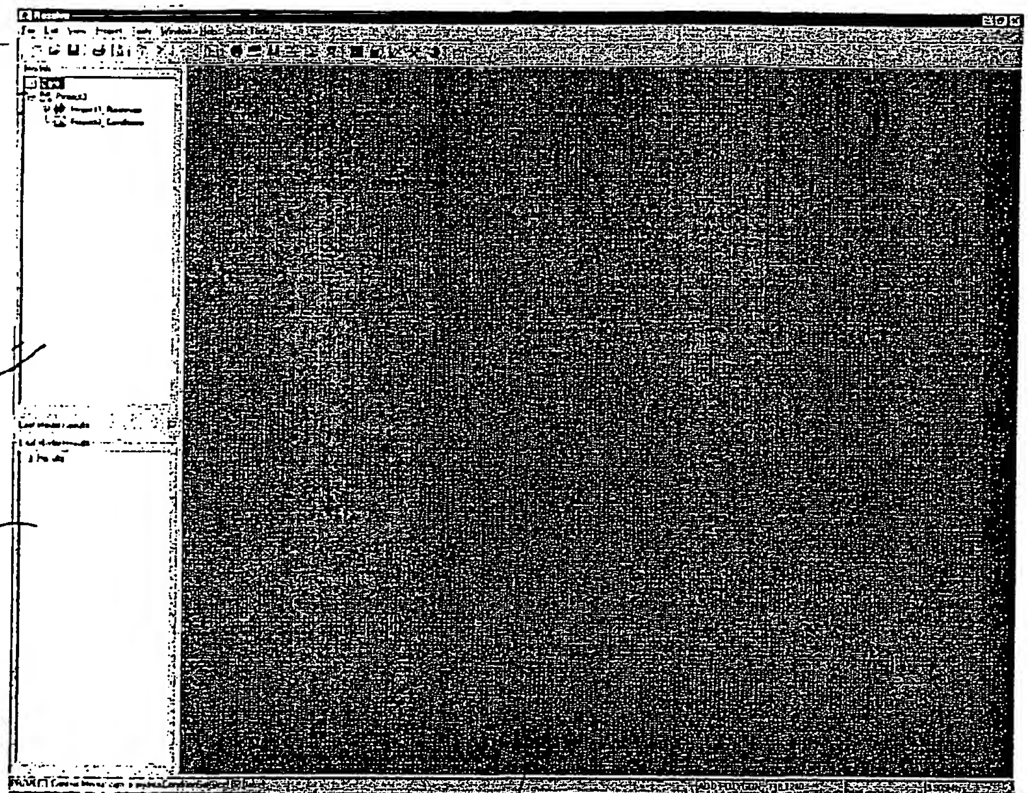


Fig 15


1650
1657
1665
1670
1620
1683
1684
1690
1692
1694
Chart Viewer: Pressure_BottomHole_Well
Well
500
1000
1500
0
1
2
3
4
5
6
7
8
9
10

1650



1620

1684

1640

135

Fig 17

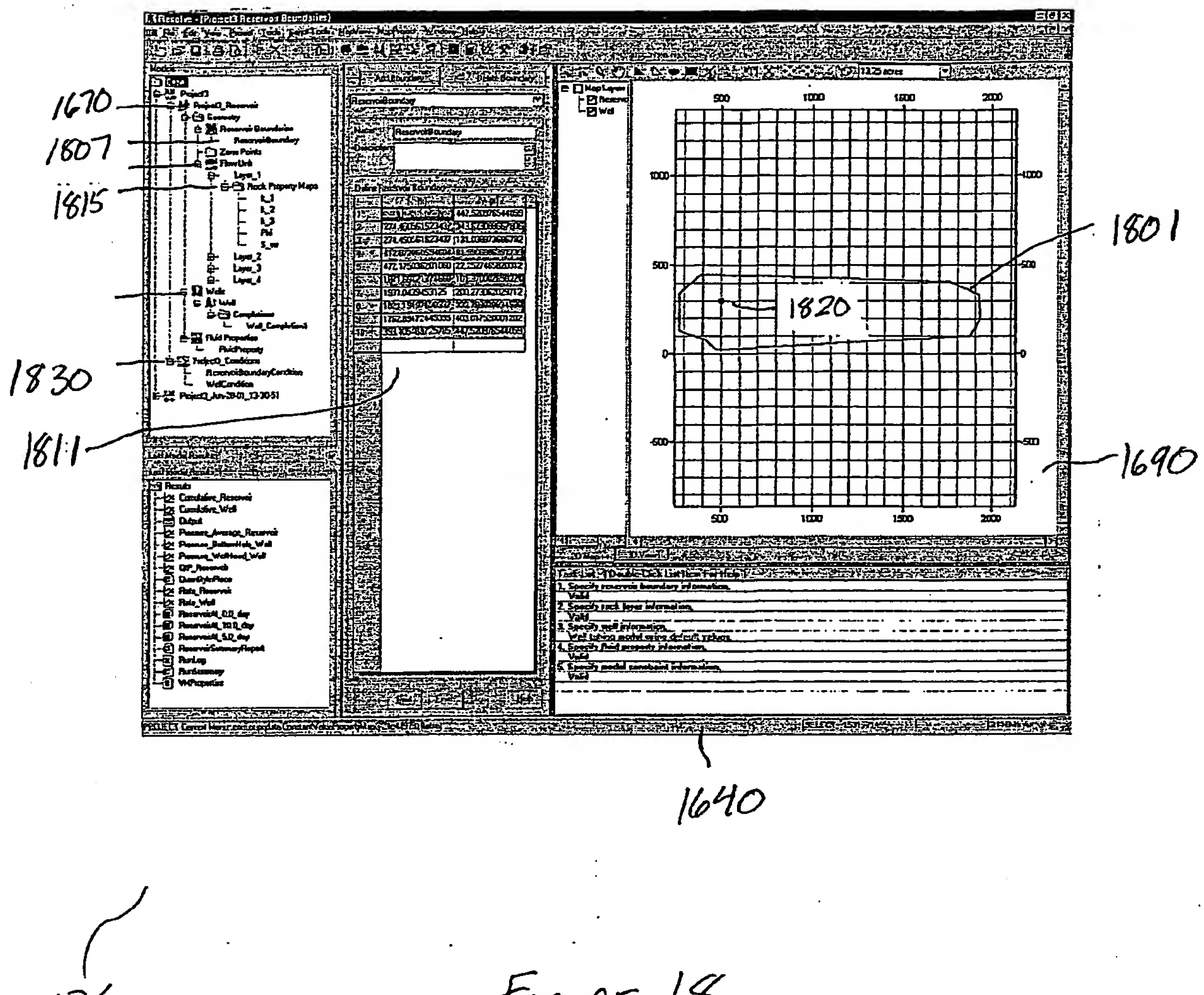


FIGURE 18

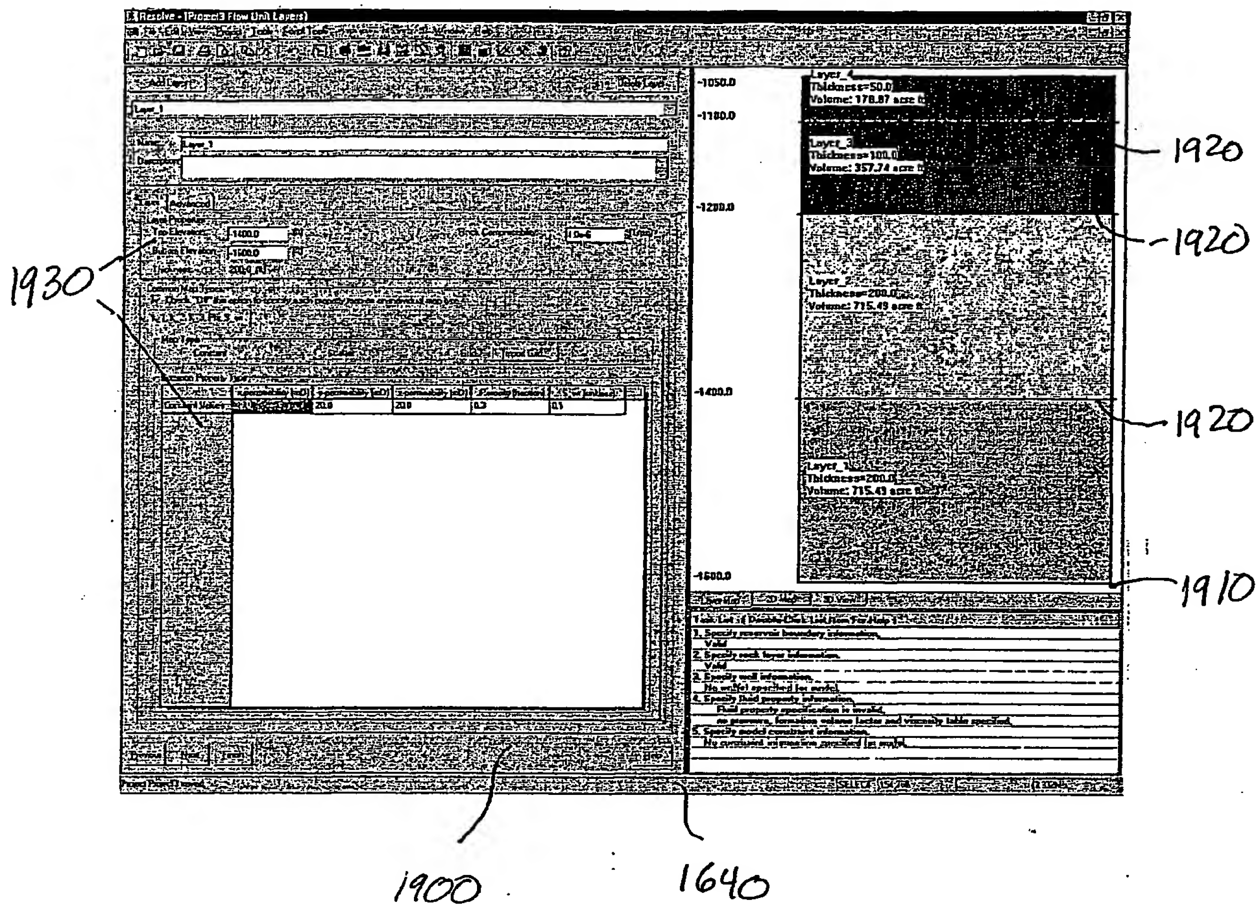
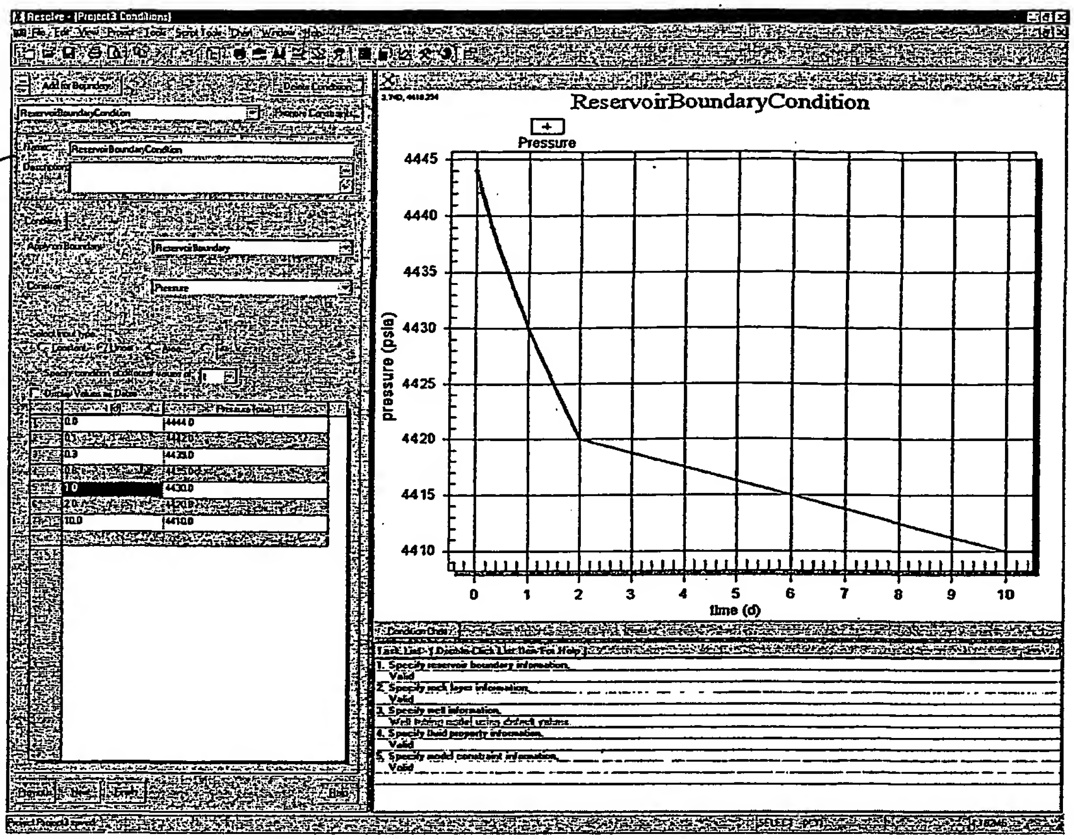

1920
1920
1920
1930
1910
1900
1640
Layer_4
Thickness=50.0
Layer_3
Thickness=100.0
Volume: 357.74 acre ft
Layer_2
Thickness=200.0
Volume: 715.49 acre ft
Layer_1
Thickness=200.0
Volume: 715.49 acre ft
-1050.0
-1200.0
-1400.0
-1600.0

FIGURE 19

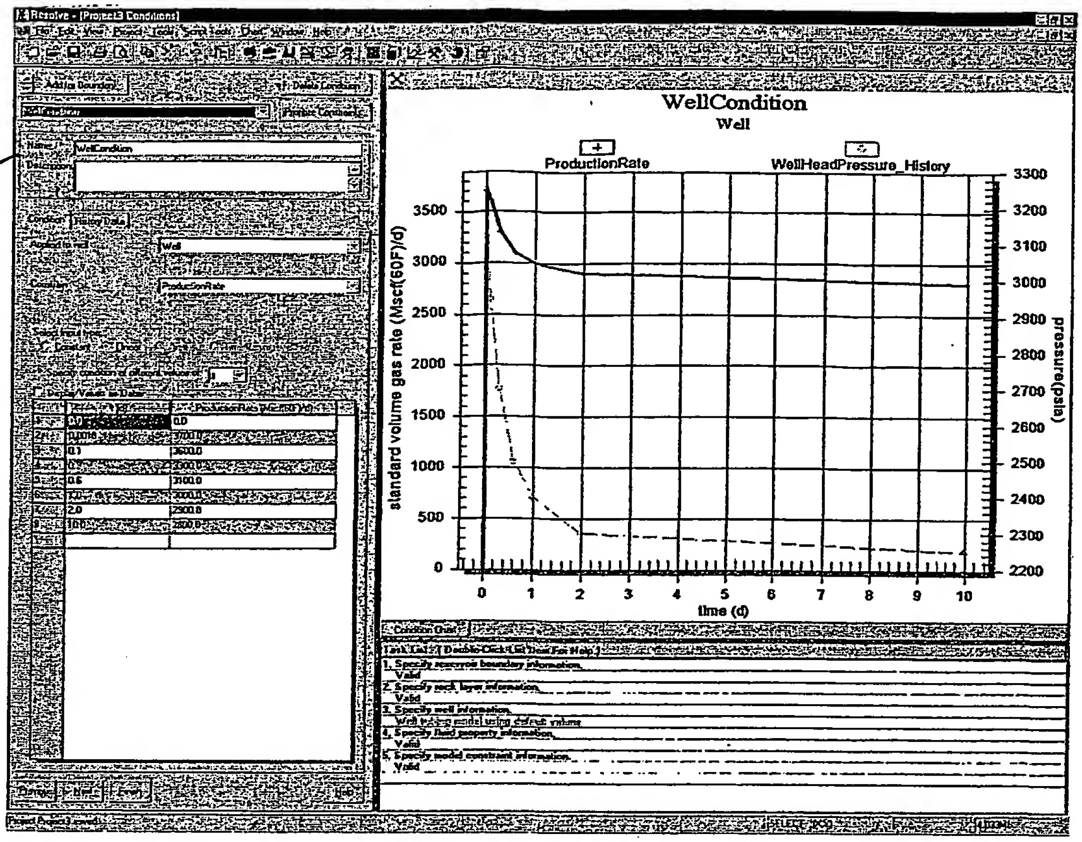
2010



135

FIGURE 20A

2010



135

FIGURE 20B

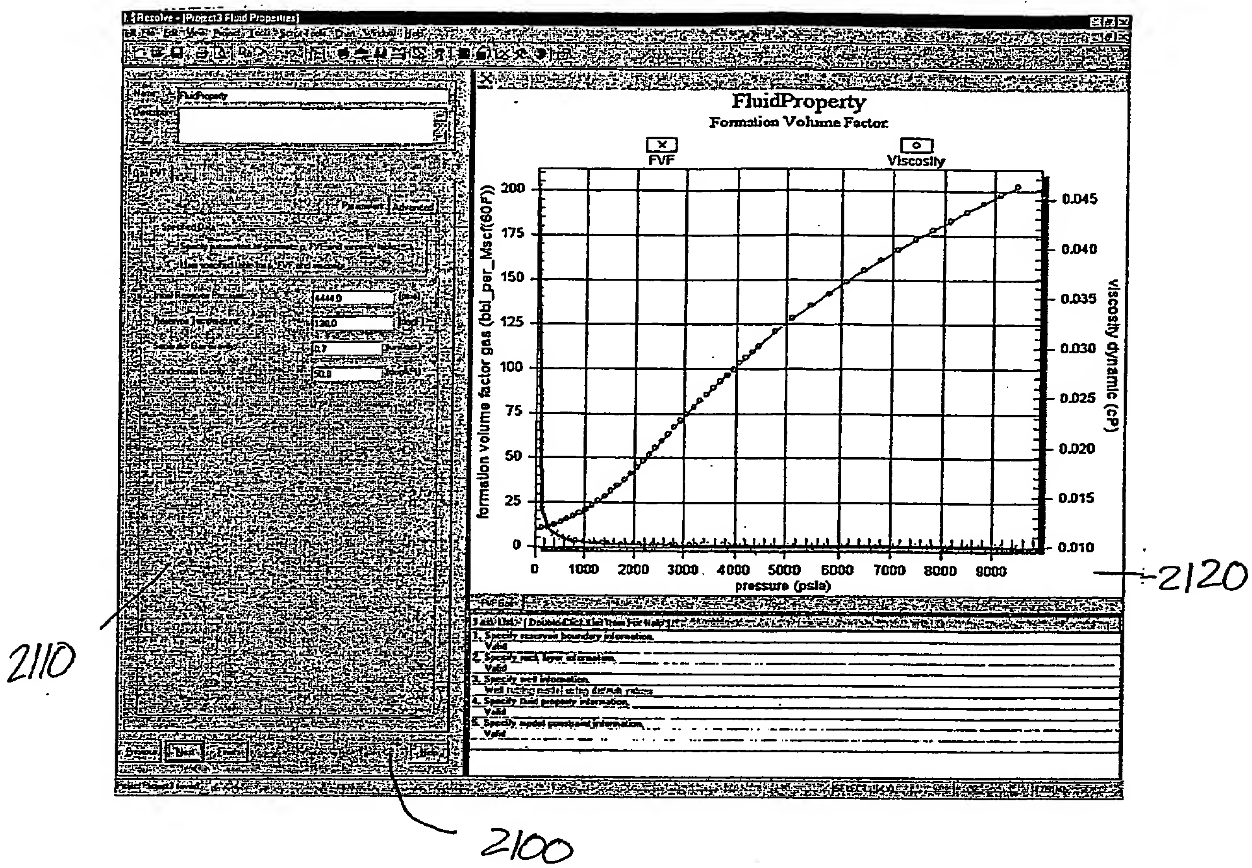
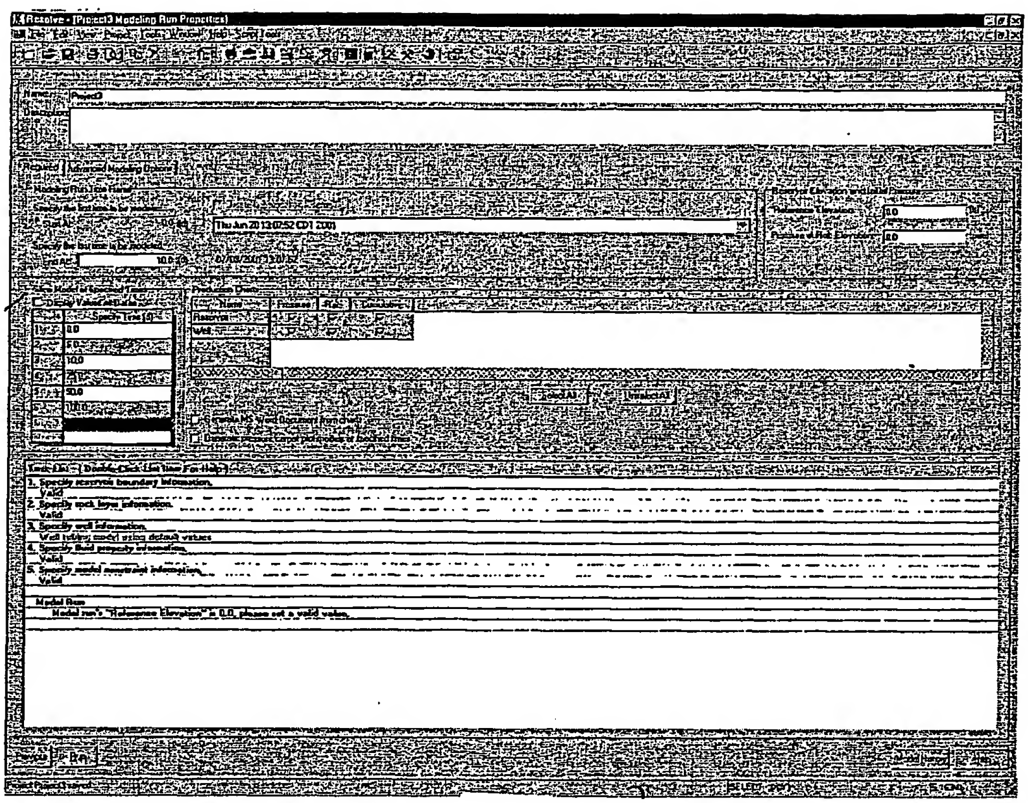

FluidProperty
Formation Volume Factor
FVF
Viscosity
formation volume factor gas (bbl_per_Mscf(60F))
viscosity dynamic (cP)
pressure (psia)
2110
2120
2100

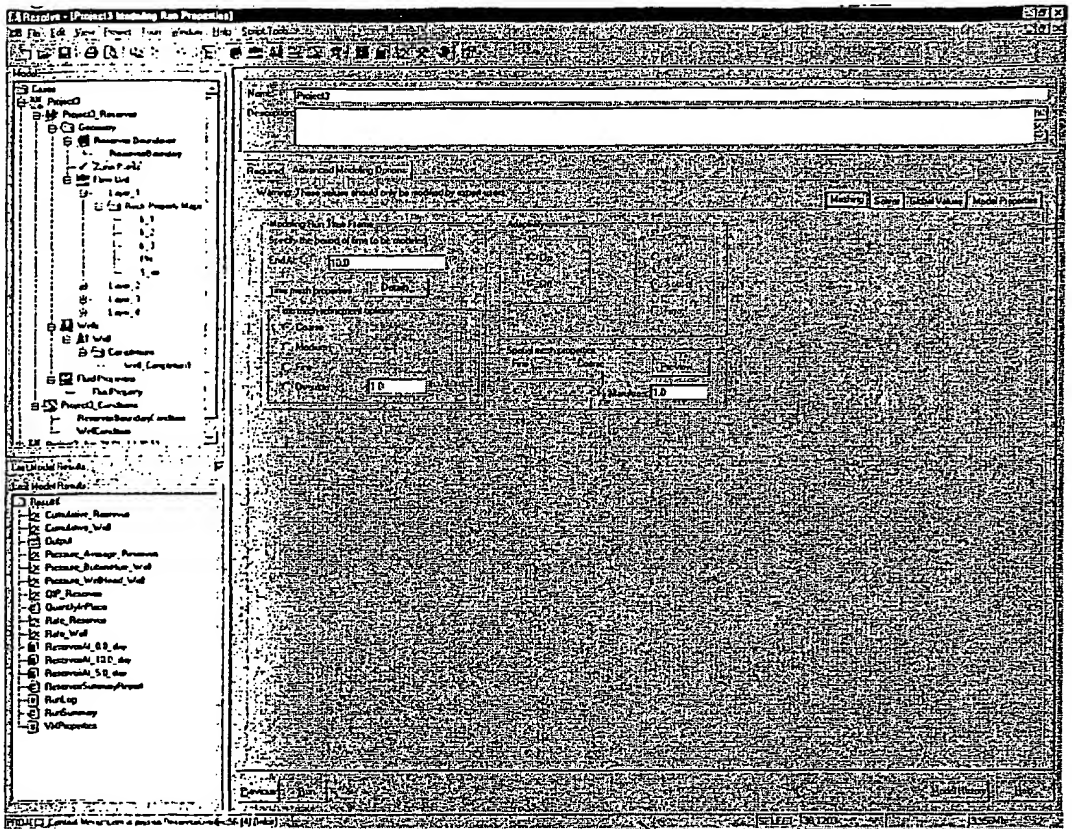
FIGURE 21



2200

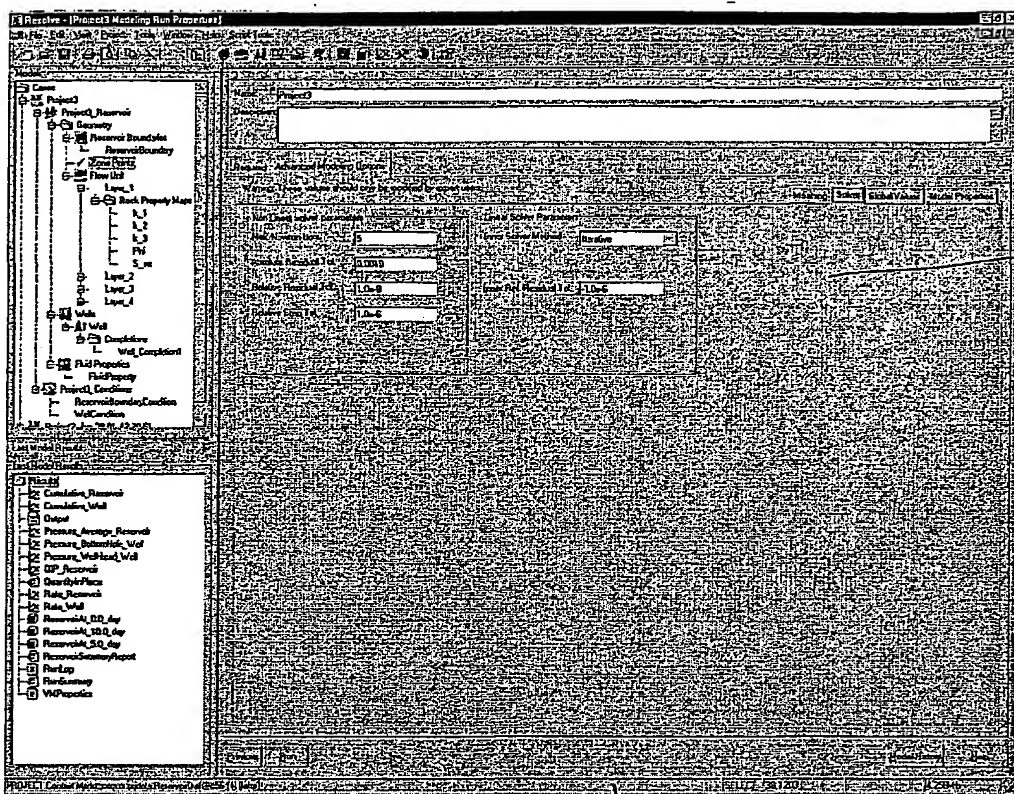
1640

FIGURE 22 A



1640

FIGURE 22B



2240

1640

135

FIGURE 22C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/20749

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01V11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01V

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, COMPENDEX, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 52048 A (SCHLUMBERGER EVALUATION & PROD) 14 October 1999 (1999-10-14) page 31, line 15 -page 41, line 10 page 41, line 13 - line 15 page 41, line 25 -page 67, line 6 ---	1-6,8, 10,11, 13,16, 18,19, 22,24, 25,28, 30-40, 45,47

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 February 2002	11/03/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lorne, B

1

International Application No
PCT/US 01/20749

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	REGTIEN J M M ET AL: "Interactive reservoir simulation" PROCEEDINGS OF THE 13TH SYMPOSIUM ON RESERVOIR SIMULATION;SAN ANTONIO, TX, USA FEB 12-15 1995, 1994, pages 545-552, XP002191280 Richardson, TX, USA the whole document ---	1,19,31, 40
A	US 6 070 125 A (REISCHER ANDREW J ET AL) 30 May 2000 (2000-05-30) column 3, line 19 - line 67 ---	1,19,31, 40
A	CHRIS BUCKALEW AND MASOUD MEHDIZADEH: "Oilfield Visualization on the PC Platform" 2000 SPE/AAPG WESTERN REGIONAL MEETING, 19 - 23 June 2000, pages 1-5, XP002191281 Long Beach, California the whole document -----	1,19,31, 40

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 01/20749

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 9952048	A	14-10-1999	AU	2848599 A	25-10-1999
			GB	2336008 A ,B	06-10-1999
			WO	9952048 A1	14-10-1999
US 6070125	A	30-05-2000	EP	1036341 A1	20-09-2000
			WO	9928767 A1	10-06-1999